PHASE II REPORT

Slurry Seal / Micro-Surface Mix Design Procedure Contract 65A0151

FOR
CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)
MATERIALS/INFRASTRUCTURE SECTION

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1.0 CHAPTER 1 EXECUTIVE SUMMARY

This report summarizes the work conducted by Fugro Consultants, Inc., Applied Pavement Technologies, MACTEC Engineering and Consultants and CEL laboratories for a study entitled "Slurry Seal/Micro–Surface Mix Design Procedure". This study was initiated in response to a request for proposals (RFP) issued by the California Department of Transportation (Caltrans) in the fall of 2002 to conduct a fourteen state pooled fund study. The objective of the study was to develop a rational mix design method for Slurry Seal and Microsurfacing.

Historically, design procedures for these mixtures have been based on empirical procedures that have little or no relationship to field performance. The current procedures are the result of extensive work done by Mr. Ben Benedict in the 1960's and 1970's with materials readily available to him in Southwestern Ohio and this work resulted in the mix design procedures contained in the International Slurry Surfacing Association (ISSA) Technical Bulletins, Performance Guidelines A-105 and A-143 and ASTM International Practices D-3910 and D6372.

After proposal review and contractual matters were concluded, a kick-off meeting took place in July of 2003. The project was designed to have three phases: Phase I consisting of a Literature review of current practices worldwide and a survey of industry and agencies using these systems; Phase II consisting of an evaluation of existing and potential new test methods, the development of a rational design procedure, and ruggedness evaluation of any new test methods developed; Phase III was intended to develop guidelines and specifications, a training program, and the construction of pilot projects to validate the recommended design procedures and guidelines.

Phase I of the project was completed in March 2004 and a report was submitted to Caltrans documenting the literature review and survey information along with a work plan for Phase II. Approval to commence work on Phase II was granted in June 2004.

The premise for the Phase II work was to measure mixing, spreading, and curing characteristics for either existing test methods or ones developed during the study. Each of the existing methods used to measure these characteristics were determined to be highly dependent on operator (technician) training and competency. For this reason the team agreed that, where possible, the test methods should be automated to reduce operator bias.

For the Phase II work, the research team selected two commonly used aggregates and two emulsified asphalts as "Standards" upon which to characterize the mixes using the current ISSA design procedures. Using the information from the literature search and industry survey, the project team selected a German automated mixing procedure to replace ISSA TB113 and the French Wet Track Abrasion test to replace ISSA TB100. The team developed a prototype schematic for an automated cohesion test and then working with an equipment vendor, Temple Systems Laboratory in Dayton, Ohio, jointly developed a "first article device which was used in the study. The materials used for the current ISSA Procedures were then evaluated using the three automated devices.

Chapters 2 and 3 of this report discuss the proposed Slurry Systems Mix Design Method and the operating characteristics of the three test methods evaluated. It should be noted that several existing ISSA test procedures, TB109 and TB 113, will continue to be used in the recommended mix design. Ruggedness evaluation for the automated mixing test (AMT) and the cohesion-abrasion test (CAT) are noted in Chapter 5. Chapter 6 contains a "Strawman" specification for slurry surfacing systems. The researchers agreed that the same tests should be conducted on the systems regardless if they were to be subjected to early traffic. The test parameters are modified to accommodate both types of conditions, and as a result the specification is named Slurry Surfacing Systems (SSS or 3S)

The appendices contain the proposed laboratory test methods for the AMT and CAT, results for ruggedness tests on two mixes using the AMT and CAT, and all the laboratory test results completed during the study.

The project was delayed several times during the course of the work because of personnel changes and testing and equipment issues. Fugro requested and was granted a one year nocost extension to the project which was originally scheduled to end in December 2007. Fugro requested another extension in October 2008, which was denied by the Contracts unit of Caltrans. This cancellation resulted in approximately \$75,000 of unspent contract funds and several areas of work not completed.

We were not able to complete the ruggedness testing on three of the five 'standard' mixes, the ruggedness testing of the automated cohesion tests (ACT), the proposed test method for the ACT, nor any of the Phase III work including validation of the new test methods and the construction or test sections.

For purposes of those who may wish to complete the study, Appendix F contains the updated work plan for Phase III and the details regarding the construction of pilot projects.

The results of the research conducted in this study indicate that the automated test procedures appear to be less variable than the current test methods and should be further analyzed for acceptance by the industry. In addition, performing the tests under several temperature and humidity conditions better approximates the conditions that will be encountered in the field when constructing these systems. Unfortunately, as noted above we were not able to verify and validate the design procedure in the field. It is highly recommended that field sections be constructed in order to accomplish this validation.

2.0 CHAPTER 2 INTRODUCTION

2.1 BACKGROUND

Slurry seals were developed and used for the first time in Germany in the late 1920's. At that time, the product consisted of a mixture of very fine aggregates, asphalt binder, and water, and was mixed by introducing the components into a tank outfitted with an agitator. It proved to be a novel approach, a new and promising technique for maintaining road surfaces, and marked the beginning of slurry seal development. However, it was not until the 1960's, with the introduction of improved emulsifiers and continuous flow machines, that real interest was shown in the use of slurry seal as a maintenance treatment for a wide variety of applications: from residential driveways to public roads, highways, airport runways, parking lots, and a multitude of other paved surfaces. (2)

Micro-surfacing was pioneered also in Germany in the late 1960's and early 1970's. (1) European scientists were looking for a way to use conventional slurry in thicker applications that could be applied in narrow courses to fill wheel ruts, and not destroy the expensive road striping lines on the autobahns. Micro-surfacing was the result of combining highly selected aggregates and bitumen, and then incorporating special polymers and emulsifiers that allowed the product to remain stable even when applied in multi-stone thicknesses. Micro-surfacing was introduced in the United States in 1980 as a cost-effective way to treat the surface wheel-rutting problem and a variety of other road surface problems. (1)

Despite the widespread use of slurry seals and micro-surfacing in the recent years, current tests and design methods are primarily empirical and are not related to field performance. The current International Slurry Seal Association (ISSA) procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143) and the corresponding American Society for Testing and Materials (ASTM) Standards D3910 and D6372 have their origin in the 1980's before the widespread use of micro-surfacing and the use of polymer modified emulsions in slurry seals. (3-6)

Recognizing the need for more rational design methods for slurry seal and micro-surfacing, the Federal Highway Administration (FHWA) enlisted the California Department of Transportation (Caltrans) to form a pooled fund study with the overall objective of developing a rational mix design method for slurry seal and microsurfacing. The improved mix design procedures, guidelines, and specifications will address the performance needs of the owners and users, the design and application needs of the suppliers, and improve the reproducibility of the test methods used for the mix designs. While differences exist between slurry seal and micro-

surfacing applications (i.e., traffic volume, application thickness, and curing mechanisms), the similarities of the tests currently used indicate that the two systems must be studied together.

The States that contributed to the pooled fund study are: California, Delaware, Georgia, Illinois, Kansas, Maine, Michigan, Minnesota, Missouri, New Hampshire, New York, North Dakota, Texas, and Vermont.

2.2 OBJECTIVES OF THE POOLED FUND STUDY

The overall goal of the pooled fund study is to improve the performance of slurry seal and microsurfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

Phase I of the project had two major components; the first consisted of a literature review and a survey of industry and agencies using slurry and micro-surfacing systems; the second part of Phase I dealt with the development of a detailed work plan for Phases II and III. The Phase I effort is complete and all findings were summarized in the Phase I Report.

In Phase II, the project team evaluated existing and potential new test methods, proposed a rational mix design procedure, conducted ruggedness tests on recommended equipment and procedures, and prepared the subject report that summarizes all the activities undertaken in Phase II.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines.

2.3 PURPOSE OF THE PHASE II REPORT

The purpose of this report is to summarize the findings and recommendations of the Phase II effort. The report provides the following:

- 1.0 The development of a preliminary mix design procedure.
- 2.0 The evaluation of new and improved tests for understanding the short term and long term properties of slurry systems.

- 3.0 Findings from the ruggedness testing program.
- 4.0 The development and evaluation of field test methods for evaluating the quality of slurry systems.
- 5.0 Updated plan for Phase III.

2.4 REFERENCES

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3.0 CHAPTER 3 DEVELOPMENT OF A RATIONAL MIX DESIGN FOR SLURRY SYSTEMS

3.1 GENERAL

This chapter presents the work plan to develop an improved mix design procedure based on performance and constructability parameters. The framework for the mix design procedure is first presented, followed by a discussion of the proposed tests to be evaluated and discussion of the plan for evaluating the ruggedness of the tests.

Please note that this Chapter does not exactly follow the Phase II outline contained in the original proposal. Upon commencement of the actual work, the project team considered the proposal outline to be in need of modification. As a result of the literature review and the surveys, the project team concurred that it was necessary to cover the essential elements in a logical fashion. For example, the proposal work plan identified a separate item for evaluating constructability parameters. However, instead of treating all matters related to construction in one place, the different aspects of construction are discussed in various sections of the report as they relate to that section.

3.2 TECHNICAL APPROACH

The ultimate purpose of a mix design procedure is to recommend the right "combination" of emulsion, aggregate, water, and additives to produce a mix that will perform under specific short-term and long-term conditions. For example, a different mix design may be needed when a quick set slurry mix is placed under high temperature-low humidity conditions versus a slow setting mix placed in low temperature-high humidity conditions. Estimated future traffic and environmental conditions should also influence the choice of a certain mix design.

However, rather than specifying the materials to be used and proportions of these in the mix, a mix design procedure specifies laboratory tests for the mix components and for the mix itself. When the results of the laboratory tests meet certain criteria, the mix design is accepted. Therefore, the designer goes through an iterative process, adjusting materials and quantities until the desired mix properties are obtained. The process is schematically illustrated in the flowchart presented in Figure 3.1.

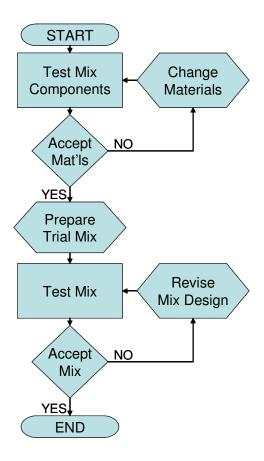


Figure 3.1: Schematic of Typical Mix Design Process

3.3 DESIRABLE FEATURES FOR A NEW MIX DESIGN METHOD

The current ISSA and ASTM procedures for the design of slurry seal and micro surfacing have their origins in the 1980's, before the wide-spread use of micro-surfacing and the use of polymer modified emulsions in slurry seals. As mentioned in the Phase I Report, the current recommended laboratory test methods have, in general, poor repeatability, limited ability to relate to field performance and do not characterize the material over the range of temperature and humidity conditions that may occur in the field. It is well known that humidity and temperature may dramatically influence the short term and long term performance of slurry seal or microsurfacing. Therefore, an effort was made by the research team to improve the current test methods or propose new test methods to address these issues. Ideally, the proposed test methods should be:

- Repeatable
- Relate to field performance

• Cover the range of temperature/humidity conditions that may occur during placement and long term performance in the field

Overall, the following desirable characteristics of the mix should be covered in the mix design:

- Mixable: The emulsified asphalt, aggregate, mineral filler, water, and control additives can be mixed, coated and applied through the machine in a continuous fashion
- Workable: The applied mixture sets to a rain-safe condition quickly without segregation, raveling, displacement, or flushing. In addition, the mix cures within a reasonably defined time period to allow return of traffic
- Performance: The mixture maintains good friction resistance, does not ravel, debond, bleed, exhibit moisture damage, or lose cohesiveness over the life of the treatment

Other features taken into account in evaluating new and existing test methods for the proposed mix design included:

- Ease of use
- Cost (as much as possible simple equipment and or adaptations of existing methods)
- Ease of implementation by users

3.4 SLURRY SEAL VERSUS MICROSURFACING

The research team discussed the possibility of having separate mix design procedures for slurry seal and microsurfacing. The differences between slurry seal and microsurfacing can be defined in terms of both chemical and performance characteristics. For the purposes of mix design, however, differences in the chemistry of the system are not relevant. In terms of field performance, the degree to which each system meets the performance requirements for traffic and environment (or fails to meet them) is the main differentiator. In terms of constructability, issues are similar for both slurry and microsurfacing (e.g., mixing, placing, finishing).

The mix design must attempt to quantify performance requirements and allow the selection of slurry or micro-surfacing systems to meet these requirements. This will not only allow for the development of appropriate specifications for a specific application to achieve the desired performance, but also should promote innovation with material suppliers to enhance or extend material performance.

For all the above considerations, the project team decided to use a single mix design procedure for both slurry seal and microsurfacing. Further, the term "slurry surfacing systems" was adopted and will be used to refer to both slurry seal and microsurfacing in the new mix design procedure. The proposed specification was named "S3" from Slurry Surfacing Systems.

3.5 LABORATORY TESTS FOR INDIVIDUAL COMPONENTS

As illustrated in Figure 2.1, in the initial phases of the mix design, the components of the mix are tested individually to ensure that each component has the desired quality and properties. The basic materials making up a slurry system are:

- Aggregate
- Mineral Filler
- Emulsified Asphalt
- Control Additives
- Water

The selection of materials, the first step of the mix design process, is an optimization process. Mixing is a function of the individual material properties and their compatibility with one another. Therefore, the performance characteristics of the mix during and after construction are affected by the individual material properties which are discussed in more detail in the following paragraphs.

3.5.1 Aggregates

The aggregate test methods used for slurry seal and micro-surfacing appear to be functional and were adopted with minimal changes for the new design procedure. Table 3.1 summarizes the requirements of the proposed S3 specification in comparison with the existing ISSA specification guidelines for slurry seal and microsurfacing.

Table 3.1: Comparison of ISSA and S3 Aggregate Requirements

Item	Test/Requirement	Method	ISSA Slurry Seal	ISSA Microsurfacing	S3
	Sand Equivalent	T176/D2419	45 minimum	65 minimum	65 min for low traffic applications
	Soundness	T104/C88	15% (Na2SO4) OR 25% (MgSO4) Maximum	15% (Na2SO4) OR 25% (MgSO4) Maximum	20% (MgSO4) Maximum
Aggregate	Abrasion resistance	T96/C131	35% maximum	30% maximum	30% max for high traffic applications 35% max for low traffic applications
	Percent Crushed	N/A	100%	100%	100%
	Micro-Deval	T327	N/A	N/A	Report
	Percent Passing 3/8 (9.5 mm)		100	100	100
	Percent Passing #4 (4.75 mm)		70 - 90	70 - 90	70 - 90
	Percent Passing #8 (2.36) mm)	T27/C136 and T11/C117	45 - 70	45 - 70	45 - 70
Type A	Percent Passing #16 (1.18 mm)		28 - 50	28 - 50	28 - 50
	Percent Passing #30 (.600 mm)		19 - 34	19 - 34	19 - 34
	Percent Passing #50 (.330 mm)		12 - 25	12 - 25	12 - 25
	Percent Passing #100 (.150 mm)		7 - 18	7 - 18	
	Percent Passing #200 (.075 mm)		5 - 15	5 - 15	5 - 15
	Percent Passing 3/8 (9.5 mm)		100	100	100
	Percent Passing #4 (4.75 mm)		90 - 100	90 - 100	94 - 100
	Percent Passing #8 (2.36) mm)	T27/C136 and	65 - 90	65 - 90	65 - 90
Type B	Percent Passing #16 (1.18 mm)	T11/C117	45 - 70	45 - 70	40 - 70
	Percent Passing #30 (.600 mm)	111/0117	30 - 50	30 - 50	25 - 50
	Percent Passing #50 (.330 mm)		18 - 30	18 - 30	18 - 30
	Percent Passing #100 (.150 mm)		10 - 21	10 - 21	
	Percent Passing #200 (.075 mm)		5 - 15	5 - 15	5 - 15
	Percent Passing 3/8 (9.5 mm)		100	-	100
	Percent Passing #4 (4.75 mm)		100	-	100
	Percent Passing #8 (2.36) mm)	T27/C136 and T11/C117	90 - 100	-	90 - 100
Type C	Percent Passing #16 (1.18 mm)		65 - 90	-	65 - 90
	Percent Passing #30 (.600 mm)	111/011/	40 - 65	-	40 - 65
	Percent Passing #50 (.330 mm)		25 - 42	-	25 - 42
	Percent Passing #100 (.150 mm)		15 - 30	-	
	Percent Passing #200 (.075 mm)		10 - 20	-	10 - 20

Note: "C" or D references an ASTM International

"CT" References a Caltrans Test Method

"T" References an AASHTO Test Method

The proposed specification requires a sand equivalent minimum of 65, a maximum of 20% magnesium sulfate soundness and allows for a maximum 30% abrasion loss for higher traffic applications. For lower traffic applications, the sand equivalent, Magnesium Sulfate Soundness and abrasion loss values are less stringent.

The recommended gradations are similar to the ones specified by the ISSA with minor changes to the percent passing No. 4 sieve and the No. 16 sieve of Type B aggregates. This was done to produce a denser grading and smoother gradation curve. In addition, the requirement for the No. 100 sieve was removed from aggregate types A, B, and C.

Two other tests were considered for the characterization of the aggregates in the new mix design method: the Methylene Blue test and the Micro-Deval test. Table 2.2 summarizes the existing and proposed tests for the evaluation of aggregates to be used in slurry systems.

Table 3.2: Summary of Laboratory Tests for Aggregates

Test Name	Test Method	Comment
Sieve Analysis	AASHTO T27 ASTM C136 CAL 202	The team considered adding requirements on fines grading less than 0.075 mm and further evaluating the aggregate size proportions.
LA Abrasion	AASHTO T96 ASTM C131 CAL 211	Aggregate hardness quality
Sulfate Soundness	AASHTO T104 ASTM C88 CAL 214	Aggregate freeze-thaw resistance
Sand Equivalent	AASHTO T176 ASTM D2419 CAL 217	Aggregate fine particle quality
Durability	AASHTO T210 ASTM D3744 CAL 229	Hardness quality of aggregates in a wet condition
Methylene-Blue	ISSA TB 145	Indicator of both clay content and reactivity
Micro-Deval	ASTM D6928	Abrasion resistance

The Methylene-Blue value, standardized against the fraction passing the No. 200 sieve, has been shown by some to be a good indicator of aggregate acceptability. The effect of filler types and the percentage addition can be monitored in this way. The evaluation of the Methylene-Blue test was carried out as part of the study. The project team agreed there was enough literature to include it in the laboratory tests and the S3 specification. The limited nature of the aggregates used meant that reactivity was essentially fixed at a range. A further study to correlate this with field performance would be necessary with a much wider range of aggregates.

In addition, a more detailed evaluation for the Micro-Deval test methods for aggregate characterization was carried out. The test is included in the proposed S3 specification as Report Only. This was thought to be useful as wear factors in the aggregate are an important failure mechanism.

3.5.2 Mineral Filler

Mineral Filler Specifications

No changes in the current specifications were considered necessary; the mineral fillers should meet the requirements of AASHTO M 17 (ASTM D242) for mineral filler and AASHTO M85 (ASTM C150) for Portland cement. Any reactivity or performance issues are addressed in other parts of the test regime for the mix itself.

3.5.3 Emulsified Asphalt and Asphalt Residue

In contrast with the ISSA guidelines, the proposed specification requires more elaborate testing requirements for emulsified asphalt and the asphalt residue, as illustrated in Table 2.3.

Table 3.3: Emulsified Asphalt and Asphalt Residue Requirements for S3 Systems

Item	Test /Requirement	Method	ISSA Slurry Seal	ISSA Microsurfacing	S3
	Emulsion type	M208/D2397		CSS-1h, quick traffic, polymer modified	
	Residue after distillation	T59/D244	60% minimum	62% minimum	60% minimum
Emulsified	Viscosity, Saybolt Furol @ 77F	T59/D244			20 – 100sec
asphalt	Storage stability, one day	T59/D245			1% maximum
	Particle charge	T59/D246			Positive
	Sieve test	T59/D247			0.1% maximum
	Penetration @77F	T49/C2397	40 - 90	40 - 90	55 - 90
	Softening point	T53/D36		135F(57C) minimum	135F(57C) minimum
Emulsion residue	Kinematic viscosity @275F (135C)	D2170		650 cSt/sec minimum	
	Ductility @77F	T51			70cm minimum
	Solubility in trichlorethylene	T44			97.5% minimum

Note: "C" and "D" refer to ASTM International test methods.

"M" Refers to an ASSHTO Standard Method.

"T" Refers to an AASHTO Test Method

The amount of asphalt in the emulsion is obtained by one of the residue recovery tests. The recovery can be done by distillation, evaporation or forced air evaporation. Ideally, a method of residue recovery that does not destroy polymer characteristics is desired.

Table 3.4 summarizes other tests methods that could be used for asphalt residue characterization. However, since it was beyond the scope of this project, it was not possible to evaluate these methods in more detail.

Table 3.4: Laboratory Tests for Asphalt Residue of S3 Systems

Test Name	Test Method	Comment
Penetration	AASHTO T49 ASTM D5	Standard & low temperature parameters; Performed at 59°F and 77°F
Ring & Ball Softening Point	AASHTO T53 ASTM D36	Index of residue flow
Dynamic Shear Rheometer (DSR)	AASHTO TP5	Stiffness parameters, G* and sin(delta)
Bending Beam Rheometer (BBR)	AASHTO TP1	Low temperature stiffness
Direct Tension Test	AASHTO TP3	Low temperature stiffness
Pressure Aging Vessel	AASHTO PP1	Aging characteristics of binder/residue

Testing of residual binders is limited by the ability to recover materials characteristics of the infield materials. This is because all the binders in use have polymer modification and the binder morphology is changed by the extraction procedures. This has been an ongoing issue in emulsion specification and is still under study. Base binders used in the emulsion and overall mechanical properties of the microsurfacing mixes should be determined as part of the emulsion selection.

3.5.4 Control Additives

The control additives used in S3 mixes are proprietary systems and the designer can only control the proportion of additive in the mix. No tests or requirements are specified at this time for control additives. This does not preclude the designers from using a range of additives based on an understanding of the chemistry of the system.

3.5.5 Water

The water used in the design and construction of S3 mixes should be potable. No changes from the current specifications are considered necessary.

3.6 LABORATORY TESTS FOR THE SLURRY MIXTURE

Laboratory tests, ideally, relate to known performance criteria. For the design of S3 mixes, the following issues are of special interest:

1. Will the materials mix?

This addresses the issues of constructability, i.e. compatibility, coating, and adhesion:

Compatibility: The chemical and physical properties of the emulsified asphalt and the aggregate influence the ability of the emulsified asphalt to bond to the aggregate and create a long-lasting slurry system. A test for "compatibility" is described in ISSA TB 115 Determination of Slurry Seal Compatibility.

Coating and Adhesion: Coating and adhesion can be evaluated using ISSA TB 114: Wet Stripping Test for Cured Slurry Seal Systems.

2. Will the mixture spread?

This covers the issues of rheology, consistency, viscosity, and break of the mixture:

Consistency: The ability of the mix to maintain consistency; in other words the elements of the mix (emulsified asphalt, aggregate, mineral filler, water, and additives) do not separate but maintain the same proportions throughout the mix. Consistency is measured using ISSA TB 106: Measurement of Slurry Seal Consistency. Consistency is important because the lack of it will cause the mix to segregate during mixing and spreading which will lead to the application of a non-uniform, poor quality material.

Break: The moment in time when, following mixing, the slurry system transitions from a fluid state to a solid state. After break, the mix can no longer be spread or finished. The time available for mixing and spreading can be measured using ISSA TB 113: Mix Time.

Viscosity: A property of the mix that can be measured while the slurry system is in a liquid state. Viscosity changes with time during mixing and spreading. When viscosity reaches a certain maximum, the mix is too stiff to be workable. The time at which this limit viscosity is reached can be used as an estimate of the available "spreading time" for the slurry system. Mixing is also a function of viscosity and a "mixing time" can be

estimated based on the increase in viscosity with time. Note that viscosity can only be measured as long as the mix is still in a fluid state.

3. Will the mixture set?

This addresses the issue of time to cure to achieve a strength that will allow traffic flow without surface damage. **Cohesion** is an indirect measure of the stiffness of the mix. Unlike viscosity however, cohesion can be measured when the mix is in a solid state. Cohesion also changes with time immediately after placement. Measuring this change in cohesion with time allows the designer to estimate the amount of time needed for the mix to cure before allowing traffic loading on the project.

4. Will the mixture last?

The long-term properties of slurry surfacing systems are dependent on their mechanical properties and the ability to maintain these properties over time and under service conditions. In this respect, slurry systems are similar to other thin aggregate/binder mixtures such as thin and ultra-thin hot mix overlays. When the material is placed in thicker layers (up to 100 mm), permanent deformation performance (rutting) becomes important and should be evaluated in the design process. The main properties of interest for long-term performance include:

- Abrasion resistance (raveling)
- Water resistance (stripping)
- Deformation resistance
- Crack resistance

3.6.1 Tests for Mixing, Spreading and Setting Properties

Table 3.5 summarizes existing and proposed tests to characterize the slurry surfacing material in the mixing and spreading stages.

Table 3.5: Tests for Mixing, Spreading, and Setting Properties of S3 Systems

Table 3.5: Tests for wixing, Spreading, and Setting Properties of 53 Systems				
Combined Materials/ Mix Property	Current/New Methods	Measured Property		
Mixing Time	ISSA TB 113	Available fluid mixing time of all components; Varying temperatures: 10 ℃, 25 ℃, 50 ℃		
Mix-ability Tests	European Cohesion Test	Initial slope of mixing torque versus time curve; mixability index		
Workability Tests	European Cohesion Test New: Torque Viscosity	Slope of mixing torque versus time curve after initial mixing; Relates to construction parameters; Increase flow resistance; Varying temperatures: 10 ℃, 25 ℃, 50 ℃		
Consistency	ISSA TB 106	Ability of fluid material to flow properly in an un-augured application box; Consistency of mixture in the spreader box stage; Motorized cohesion test or simple cup flow test; Varying temperatures: 10 °C, 25 °C, 50 °C		
Spread-ability Test	New: Torque Viscosity	Slope of torque curve vs. time defined as exiting from mixing box (shear modulus)		
	ISSA TB 139	Identification of curing time for earliest traffic ability; Varying temperatures: 10 ℃, 25 ℃, 50 ℃		
Curing Time	HILT Bend Test French Test	Identify internal cohesion at traffic time; Varying temperatures: 10 °C, 25 °C, 50 °C		
	European Cohesion Test	Identify the build up in cohesion over time; Varying temperatures: 10 ℃, 25 ℃, 50 ℃		
	Oven-cured specimens	Relate cure time test by comparison of oven-cured specimens		
Traffic-ability Test	New	Compaction test to determine how long it will take for mix to reach final in-place voids		
	New	Permeability of specimens for determining compaction ability		
Additive Effectiveness	Above test methods	Determining the effects of different additives and varying quantities; Varying temperatures: 10 ℃, 25 ℃, 50 ℃		

Of the many tests listed in Table 3.5, the project team saw a great potential in the European Mixing Test. Also, it became apparent that ISSA TB 139 could be automated/computer controlled to minimize operator-induced variability. The two tests are described in more detail in the following paragraphs.

3.6.2 The European Mixing Test

Based on the test evaluation criteria presented in Section 3.2 of the report (Technical Approach), ISSA TB 113 was proposed for use as a basis to determine the mixing time. The test can be used as a very good indicator of compatibility of the mix components as well as to estimate the available mixing time for the slurry system. However, the test is highly variable, largely because:

- stirring (mixing) is carried out by hand and will vary to one operator to another
- the assessment of the viscosity of the mix is also subjective and will be different from one test operator to another

As an alternative, a more rational, automated test procedure was needed. The project team considered the European mixing test, which was later called the Automated Mixing Test or AMT. In this test, the slurry system components are mixed in a cup similar to the one used in TB 113. However, mixing is carried out with an automated motor. The device measures changes in viscosity (torque) with time, during the mixing process, and is shown in Figure 3.2. In Figure 3.3, a schematic of the device and its components are shown.

The test can be used to determine a mixability parameter (cohesion limit where coating occurs to >95 percent) and a workability parameter (a cohesion value where the mix will still flow). These can be defined by observing the consistency and be quantified by the cohesion value and shape of the mixing curve. An example of this curve is provided in Figure 3.4. These parameters could be measured over a range of shear values, temperatures, and other parameters.

The mixing test uses a torque transducer to measure stiffness of a mix and it is similar to TB 106. However, the test method is computerized and standardized and has been under development in Europe for a decade.



Figure 3.2: European Mixing Test

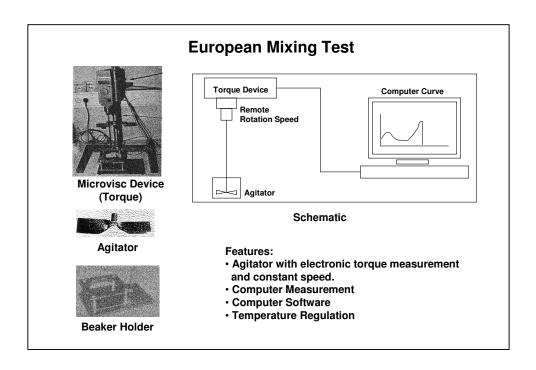


Figure 3.3: European Mixing Test Schematic

The intent of the automated test procedure is to remove operator variability and be easy to run at the same time.

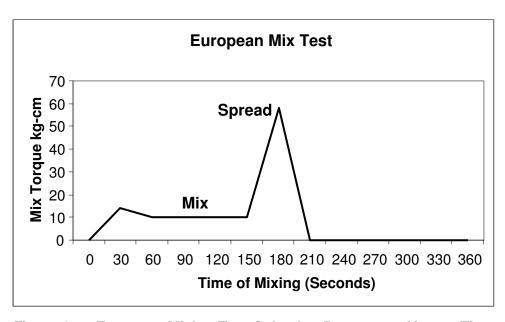


Figure 3.4: European Mixing Test Cohesion Parameters Versus Time

The test data would be evaluated by observing the mix parameters noted above as compared to results from TB 113. In addition, the coating of the aggregate would be evaluated visually as is currently done. This test would determine the preliminary range of mix proportions.

Starting from the European mixing test, the team purchased the equipment and carried out series of tests to optimize the test for use in slurry seal design. The development and evaluation of this test method is discussed in detail in Chapter 4.

3.6.3 The Automated Cohesion Test (ACT)

The next step in the mix design process is to determine the traffic time. This is a constructability parameter, or a measure of the cohesion the mix must reach in order to accept traffic. This level should be the same for any traffic type, but it may require different times at other application conditions (e.g., temperature, time of day, anticipated rainfall).

The cohesion measurement is thus very important to ensure the mix will perform under traffic. This property will be based on TB 139 to determine the mix and set traffic cohesion as well as a 24-hour cohesion. This may be measured under a range of conditions of humidity, temperature, and ambient light to determine the suitability of mixtures for specific application conditions.

Figure 3.5 is a schematic indicating the intended output from the test. The test determines the minimum requirement for cohesion based on TB 139 and acceptable mixtures at standard conditions. It also determines the cohesion requirements at a nominal traffic time of 60 minutes. The 24-hour cohesion can be based on project specific cure conditions. A fully cured value may also be established using oven-cured samples. The test provides three specification points for cohesion: mixing, spreading, and traffic. Figure 3.6 is a schematic drawing of the equipment.

As mentioned earlier in this report, the test method is subject to operator variability. To reduce this unwanted effect, the project team developed an automated cohesion tester. Further details are given in Chapter 4.

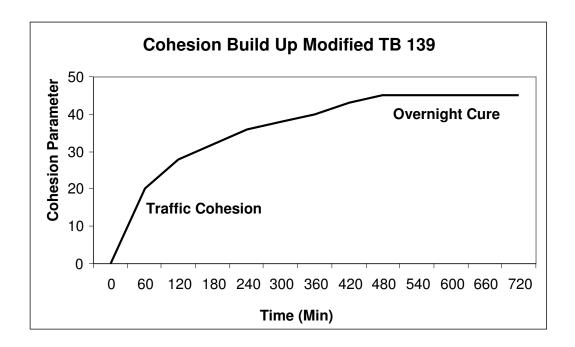


Figure 3.5: Modified TB 139 Cohesion Parameters Versus Time

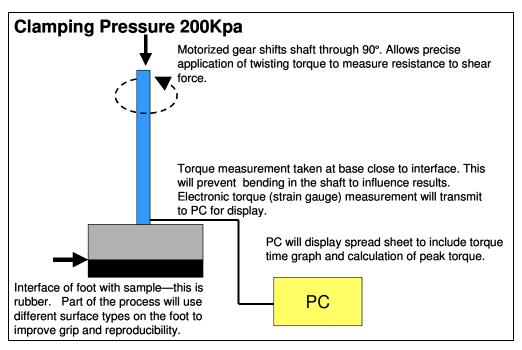


Figure 3.6: Schematic of the Initial Cohesion Test Method

The Hilt test was also considered for measuring cohesion, but was rejected for the mix design due to reported repeatability issues.

3.6.4 The Cohesion-Abrasion Test (CAT)

Another test that was investigated in more detail by the team is a modified version of the Wet Track Abrasion Test (WTAT), ISSA TB 100. Although not listed in Table 3.5, the modified WTAT can be used on test samples similar to those for the wet cohesion test to evaluate the increase in strength of a slurry system in the period after placement and before opening to traffic.

As shown in Figure 3.7, the modification consists in the use of a set of wheels instead of the standard abrasion head. Abrasion loss and short-term stone retention may be measured in this test. The test may be performed under different cure conditions to determine the effect of early water intrusion due to rain. Development of this test method is described in detail in Chapter 4.

Results from this test can be used to establish a limit for stone retention with respect to cure at time and conditions. Samples should be cured under the following three laboratory conditions:

- Laboratory "standard" conditions (25°C, 50 percent relative humidity).
- Oven at 60^oC.

• Humidity and temperature bath (10°C, 90 percent relative humidity; 40°C, 90 percent relative humidity).

Figure 3.8 shows a simple conditioning system for humidity /night-time curing of samples that has been used in an actual field project. The space at the bottom may contain water with ice for low temperature-high humidity, or hot water for higher humidity. A cooler or heater and a thermostat control the water temperature.

3.6.5 The Loaded Wheel Test (LWT)

The LWT may be used to establish the upper limit of bitumen content by determining the amount of sand adhesion in accordance with TB 109. Determining the upper bitumen limit is important to prevent bleeding of mixes in service and this test should be modified to include different conditions. The test will be used as is, but conditioning of samples will be carried out at 15°C, 25°C, and 35°C to allow for the effects of high shear or high temperature. Deformation in early life is evaluated using cohesion testing.

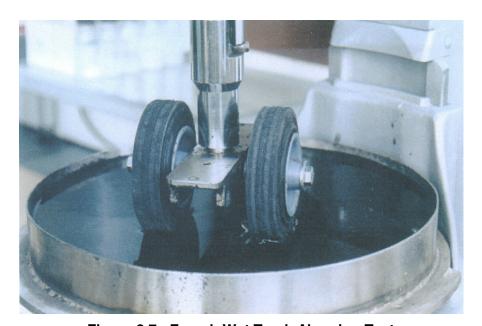


Figure 3.7: French Wet Track Abrasion Test

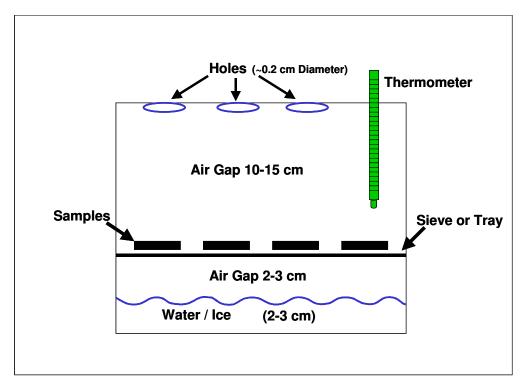


Figure 3.8: Proposed Curing/Conditioning System

3.6.6 Long Term Performance Tests

The long-term properties of S3 mixes are dependent on their mechanical properties and their ability to maintain these properties over time and under service conditions. This makes them no different from any other thin aggregate/binder mixtures such as thin and ultra-thin hot mix overlays. For high traffic or rut filling applications, when the material is placed in thicker layers (up to 100 mm), performance becomes important and must be evaluated in the design process. Table 3.6 provides a list of candidate tests that were identified in the original proposal.

Table 3.6: Candidate Long Term Performance Tests

Combined Materials	Current/New Methods	Defined Property
	Current/New Methods	·
Initial Target Residual Asphalt Content		Film thickness determinations based on surface area and sieve analysis
Coatability	ASTM D244	Coating characteristics
Wet Stripping	ISSA TB 114 ASTM D3625	Boiling water adhesion
Durability/ Aging/ Stripping	ISSA TB 114 ASTM D3625	Testing compacted mix samples after PAV curing; Stripping test by boiling of aged and un-aged specimens
Stripping Resistance	AASHTO T283	Moisture sensitivity of compacted specimens
Wet Track Abrasion	ISSA TB 100 Modified with French Wheel Method	Minimum asphalt requirements under wet abrasive conditions; One hour soak; Varying soaking conditions of time and temperature
Abrasion Test for cured specimens	ISSA TB 100 Modified with French Wheel Method	Effect of wear on pavement surface over the life. Aging indication on PAV-based or oven-based specimens
Water Sensitivity under wheel load	Modified Hamburg Test	Deformation resistance and water resistance utilizing various testing conditions on the Hamburg test equipment
Water Sensitivity Test	ISSA TB 100	Minimum asphalt requirement under wet abrasion conditions; Six day soak; Varying soaking conditions of time and temperature
Volumetric Criteria	Voids determination before and after compaction New method	Optimize asphalt content based on volumetrics; Determine voids- in-place requirements which would give a mechanical set of properties at allowable residual binder levels
Permeability	NCAT procedure	Determine voids permeability at varying asphalt contents
Excess Asphalt	ISSA TB 109	Maximum asphalt content requirement by measurement of hot sand
Crack Resistance Fatigue Testing	Bruge Bending Test- Modified Reflection Cracking JIG Fatigue Thin Slice	Cracking resistance using fatigue testing or flexural testing
Fuel Resistance	ASTM D	Fuel resistance determinations; Varying residual asphalt contents
Pick up	Modified Hamburg Test	Determining optimum asphalt content which would give acceptable pick up per Hamburg test at varying laboratory environmental conditions
Modulus Loss	Indirect Tensile Test	Modulus test on briquette using an Indirect Tensile test
Lateral Displacement	ISSA TB 147	Measurement of lateral deformation under Loaded Wheel Tester
Deformation Resistance	ISSA TB 147 Hamburg/Creep/Modulus	Deformation of multi-layered system

The main properties of interest for long-term performance include:

- Abrasion resistance (raveling)
- Water resistance (stripping)
- Deformation resistance (rutting)

The test methods that are recommended for inclusion in this study are included in Table 3.7. The project team considers that the criteria in Section 3.3 is met by these tests. A summary of the long term performance tests are as follows:

- Abrasion: TB 100 modified WTAT. This test may be conducted on fully (oven cured) samples under water and with various conditioning methods including soaking at different temperatures and times, and different curing cycles.
- Water Resistance: The modified WTAT will be carried out for extended times on fully cured samples under elevated temperature under water. This will be expressed as a ratio of 1-hour soak to 6-day soak and a limit set for acceptable mixes of retained abrasion resistance.
- Deformation Resistance: The existing TB109, Loaded Wheel Test, will be used to evaluate deformation characteristics.

Table 3.7: Long Term Performance Tests included in S3 Specifications

Long Term Performance Tests	Test Method	Defined Property
Abrasion Resistance	Modified TB 100	Raveling
Water Resistance	Modified TB 100	Resistance to moisture damage
Permanent Deformation	ISSA TB 109	Deformation characteristics

3.6.7 The Asphalt Pavement Analyzer Test (APA)

Due to budget limitations, the APA test was not evaluated in this study. However, the team recommends that future research be conducted regarding the use of the APA as an alternative to the Loaded Wheel Tests (LWT) to evaluate the permanent deformation properties of slurry systems used for rut-filling applications.

3.7 PROPOSED S3 SLURRY SYSTEMS MIX DESIGN METHOD

The proposed mix design procedure is shown in Figure 3.9. The design procedure addresses the shortcomings of the existing procedures by examining mix properties that relate to field performance issues. The steps in the proposed mix design procedure are described below.

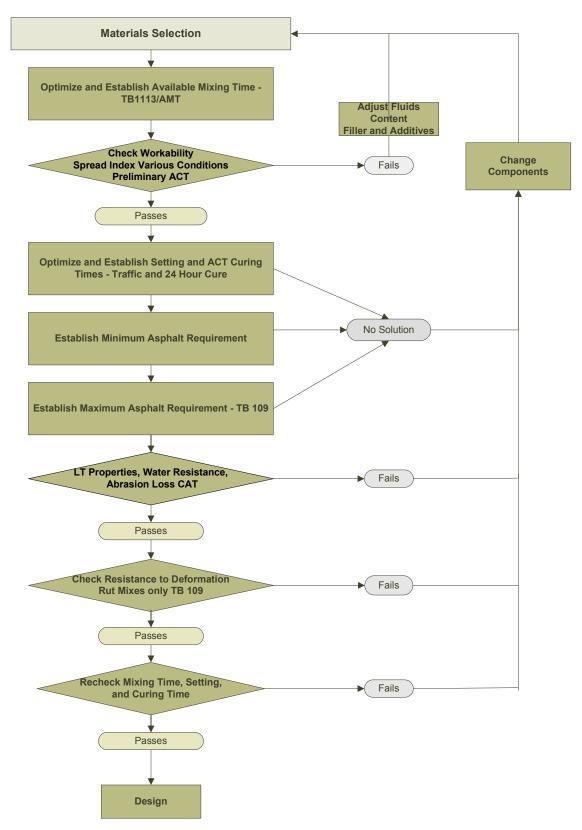


Figure 3.9: Proposed S3 Mix Design Procedure

3.7.1 Step 1: Materials Selection

To begin the mix design, the current ISSA recommendations will be used. Step 1 is subdivided into the following steps, in the order given:

- Selection of aggregate: The first step is to choose the aggregate grading based on the existing ISSA specifications. In addition, the selected aggregate must meet the minimum requirements for mechanical and chemical properties in the specifications prepared as a result of this study.
- Selection of the emulsion and binder: This will be largely a matter of the climatic conditions where it will be applied, and available supply. These parameters are included in the project's specifications.
- Selection of a locally available potable water source.
- Selection of a mineral filler, Portland cement, or hydrated lime, which meets the specification requirements.
- Selection of a liquid retardant such as Aluminum Sulfate when necessary.
- Include a set control additive at the addition rate recommended by the emulsion supplier if necessary.

3.7.2 Step 2: Create a Mix Matrix and Determine Mix Constructability

After the materials have been selected, it will be necessary to determine the proportions of aggregate, water, emulsion, and additives to create a mix matrix. This step will involve the use of the AMT test to determine the mix and spread indices. With the results of the AMT, the conditions at which the materials can be mixed safely and placed in a timely fashion can be determined. These tests will be performed at standard laboratory conditions and repeated for selected mixes for a range of anticipated application conditions.

This process should be repeated with different filler types (if necessary) to optimize the mixture for constructability and performance criteria. This will lead to a recommended filler type and additives levels to be used.

3.7.3 Step 3: Allowable Field Adjustment

This step consists of taking the acceptable mixes and conducting cohesion testing using the ACT. The cohesion test is performed at 60 minutes and after 24-hours of cure. This testing would be repeated for specified application conditions of the project. If the results do not meet the standards, then the mixes and materials would be modified as required. In all cases, it is

important to ensure that the mix time and spreadability are acceptable. Spreadability is a measure of the ability of the mix to be placed and finished on the pavement surface.

After the proportions have been selected, the ACT test should be performed and repeated for anticipated curing conditions to evaluate the short-term abrasion properties.

The mix proportions can then be modified if necessary and a check performed to confirm that the cohesion at 60 minutes provides an acceptable traffic time and the cohesion at the 24-hour cure period is also acceptable.

The results of step 3 are used to establish a target optimum for the next step in the design, and to evaluate the short-term abrasion properties of the selected mix.

3.7.4 Step 4: Determine the Optimum Binder Content

This involves preparing selected samples for the specific application conditions and varying the emulsion content ± 2 from the target optimum. The additive and filler proportions will remain as determined from the targets developed in step 3.

Under this step the WTAT will be performed at 1-hour and 6-day soak periods followed by tests using the LWT to determine the excess asphalt at the temperature that corresponds to the proposed traffic conditions (i.e., heavy at 95°F, moderate at 77°F, and low at 59°F).

The recommended optimum binder content will be selected by evaluating the abrasion loss in the WTAT test and the binder content versus sand adhesion from the Loaded Wheel Tester (LWT).

NOTE: The specification minimums established by this study will be used for abrasion loss and the maximum for sand pick up from the LWT.

3.7.5 Step 5: Evaluate the Cohesion Properties at Various Curing Conditions

The selected curing conditions should be representative of the project's estimated humidity and temperature conditions at the time of construction. CAT test is then performed at 30 minutes, 1 hour, and 3 hours.

3.7.6 Step 6: Evaluate the Long Term Properties of the Mixture

This step consists of evaluating the following:

- Abrasion: Using the CAT.
- Water Resistance: Using the Modified WTAT.
- Deformation (rut-filling mixes only): TB 109

Finally, any necessary adjustments and recheck of the mixing indices (spread ability, traffic, and 24 hour cohesion) will be made.

After selecting the best mix from the short-term test methods noted above, the mix will be tested for the following long-term performance properties:

- Abrasion resistance
- Water resistance
- Deformation

3.7.6.1 Abrasion Resistance

This property will be measured using the CAT test using fully cured specimens, soaked for 6 days, under project specific environmental conditions.

3.7.6.2 Water Resistance

The CAT abrasion test will be run on the final mix design after being soaked for 6 days at a temperature of 77 °F and comparing the loss to that of a 1-hour soak and express this as a ratio. This information will be compared to the results of an existing mixture in order to determine the appropriate specification limits. The test will then be checked with a mix of known standard properties using other materials with which the team and advisory group have experience.

3.7.6.3 Deformation

This property will be measured using TB109 "Excess Asphalt by LWT Sand Adhesion".

4.0 CHAPTER 4 LABORATORY EVALUATION OF PROPOSED TEST METHODS

4.1 EXPERIMENTAL MATRIX

Two aggregates and two asphalt emulsions were initially used in the laboratory test program. Four slurry systems (mixes) were created using all possible combinations of aggregate and emulsion:

Aggregates:

- A1 George Reed, Inc. Table Mountain, Sonora, CA (ISSA Type III)
- A2 Lopke Gravel Products, Lounsberry Pit, Nichols, NY Products (ISSA Type III)

Emulsions:

- E1 Sem Materials (Koch), Tulsa, OK, Ralumac
- E2 VSS Emultech, Polymer Modified LMCQS-1h, W. Sacramento, CA

A third aggregate and emulsion were acquired during the third quarter of 2006. The aggregate (A3) is a Sandstone from Delta Materials in Marble Falls, TX, and the emulsion is from Ergon Asphalt and Emulsions, Inc., (E3) from their Waco, TX, plant. The aggregate and emulsion were used to design the "unknown" mix, denoted M5:

Aggregate:

A3 Delta Materials, Marble Falls, TX

Emulsion:

E3 Ergon Asphalt & Materials, Waco, TX

The experimental mixes and combinations are noted in Table 4.1.

Table 4.1: Experimental Matrix

System	Aggregate + Emulsion Combination
M1	A1+E1
M2	A1+E2
M3	A2+E1
M4	A2+E2
M5	A3+E3

4.2 LABORATORY TEST METHODS DEVELOPMENT

4.2.1 Development of the Automated Mixing Test (AMT)

In the development and verification of the AMT, the decision was made to begin with the existing trial mix procedure included in ISSA TB 113. This would provide the basis for comparing the results of an accepted and widely used procedure to the new process. In addition to TB 113, a consistency description is included in the new test method.

Mixing Test (TB 113)

The mixing test, TB 113, was run on the five systems noted above and a matrix of aggregate and emulsion proportions were determined based on past experience with these mix types.

Results for the mixes M1 through M5 using the current T 113 procedure with the inclusion of the consistency description are contained in the following tables. Additional data for these mixes is contained in Appendix E.

Table 4.2.1: TB113 Results for Mix M1 (A1+E1)

Formulation	Parts I	by dry we	ight of a	ggregate, g	9	Mix time,	Blot Test,	Coating	Consistency
Formulation	agg, g	cement	water	additive*	emulsion	sec	30 sec	Visual/boiling	Description
1	100	1.0	9.0	0.50	13.0	>120	CW	100/98	St
2	100	1.0	8.0	0.50	14.0	>120	CW	100/98	LV
3	100	1.0	8.0	0.50	15.0	>120	CW	100/98	S
4	100	1.5	8.0	0.50	14.0	>120	CW	100/98	LV
5	100	1.5	8.0	0.50	14.0	>120	CW	100/98	MV
6	100	1.0	8.0	0.50	14.0	>120	CW	100/98	MV
7	100	1.0	8.0	0.50	13.0	>120	CW	100/98	LV
8	100	1.0	8.0	0.25	14.0	>120	CW	100/98	LV
9	100	1.5	8.0	0.25	14.0	>180	CW	100/98	LV

^{*5%} emulsifier solution

Consistency	Blot Test
S = Soupy (Brown free liquid, segregating sample)	A = Aggregate and clear water
LV = Low Viscosity (Non segregating easy to mix)	BT= Brown transfer
MV = Moderate Viscosity (Non segregating, moderate resistance to mix)	CW= clear water
St = Stiff (Hard to mix but workable)	
B = Broken (Lumps, non consistent)	

Based on the data contained in Table 4.2.1, the mixture components selected for the AMT for Mix M1 are as follows:

Aggregate 100 grams

- Cement 1.0%
- Water 8% (Based on the weight of dry aggregate)
- Emulsion 14-15%
- Additive 0.5% Aluminum Sulfate

The resulting mix had the following characteristics:

- Mix displays a narrow range of consistencies
- At lower mix viscosities, the consistency is soupy with a tendency for the aggregate to segregate and the emulsion to darken in color
- Proceeded to clear water very quickly

In addition to the "base mixture" noted above for M1, components were varied to produce additional mixtures with the following consistencies for further testing:

- Soupy
- Low Viscosity
- Medium Viscosity
- Stiff

The purpose of testing different consistencies is simply to select the best target mixture for further evaluation.

Table 4.2.2: TB113 Results for Mix M2 (A1+E2)

Formulation	Parts I	by dry we	ight of a	ggregate, g	g	Mix time,	Blot Test,	Coating	Consistency
Formulation	agg, g	cement	water	additive*	emulsion	sec	30 sec	Visual/boiling	Description
1	100	0.0	8.0	0.00	11.0	>180	BT	100/95	foam ,LV
2	100	1.0	8.0	0.00	12.0	>180	CW	100/98	MV
3	100	1.5	8.0	0.00	12.0	>180	CW	100/98	MV
4	100	1.5	8.0	0.25	12.0	>180	CW	100/98	MV
5	100	1.5	8.0	0.25	13.0	>180	CW	100/98	MV
6	100	1.5	8.0	0.25	14.0	>180	CW	100/98	MV
7	100	1.5	8.0	0.50	12.0	>180	CW	100/98	MV
8	100	1.5	8.0	0.50	13.0	>180	CW	100/98	MV
9	100	1.5	8.0	0.50	14.0	>180	CW	100/98	MV
10	100	2.0	9.0	0.00	14.0	>180	CW	100/98	MV
11	100	2.0	8.0	0.50	14.0	>180	CW	100/98	MV
12	100	2.0	9.0	0.50	15.0	>180	CW	100/98	LV

^{*5%} emulsifier solution

Consistency	Blot Test
	A = Aggregate and clear
S = Soupy (Brown free liquid, segregating sample)	water
LV = Low Viscosity (Non segregating easy to mix)	BT= Brown transfer
MV = Moderate Viscosity (Non segregating, moderate resistance to mix)	CW= clear water
St = Stiff (Hard to mix but workable)	
B = Broken (Lumps, non consistent)	

Based on the data contained in Table 4.2.2, the mixture components selected for the AMT for Mix M2 were as follows:

- Aggregate 100 grams
- Cement 1.5%
- Water 8% (Based on the weight of dry aggregate)
- Emulsion 13-15%
- Additive 0.25% Aluminum Sulfate

The resulting mix had the following characteristics:

- Very stable and displayed a wide range of compositions
- Very quick set
- Proceeded to clear water and exhibited cohesive form

In addition to the "base mixture" noted above for M2, components were varied to produce mixtures with the following consistencies for further testing:

- Soupy
- Low Viscosity
- Medium Viscosity
- Stiff

Table 4.2.3: TB113 Results for Mix M3 (A2+E1)

Formulation	Parts	by dry we	ight of a	ggregate, g	9	Mix time,	Blot Test,	Coating	Consistency
Formulation	agg, g	cement	water	additive*	emulsion	sec	30 sec	Visual/boiling	Description
1	100.0	1.0	9.0	0.50	13.0	60	-	-	В
2	100.0	1.0	9.0	0.25	12.0	90	-	-	В
3	100.0	1.0	10.0	0.25	13.0	120	-	-	В
4	100.0	1.0	10.0	0.25	14.0	>120	Α	90/85	LV
5	100.0	1.0	10.0	0.50	16.0	>120	Α	90/85	MV
6	100.0	1.0	9.0	0.50	14.0	>120	-	90/85	St
7	100.0	1.0	9.0	0.50	14.0	100	-	95/85	В

^{*5%} emulsifier solution

Consistency	Blot Test
S = Soupy (Brown free liquid, segregating sample)	A = Aggregate and clear water
LV = Low Viscosity (Non segregating easy to mix)	BT= Brown transfer
MV = Moderate Viscosity (Non segregating, moderate resistance to mix)	CW= clear water
St = Stiff (Hard to mix but workable)	
B = Broken (Lumps, non consistent)	

Based on the data contained in Table 4.2.3, the mixture components selected for the AMT for Mix M3 are as follows:

- Aggregate 100 grams
- Cement 1.0%
- Water 10% (Based on the weight of dry aggregate)
- Emulsion 14-16%
- Additive 0.5% Aluminum Sulfate

The resulting mix had the following characteristics:

- Mix displays a narrow range of consistencies
- At higher viscosities, the mix is moderate to stiff with a tendency for the mix to have a slower break reaction
- Proceeded to aggregate and clear water for blot evaluations

In addition to the "base mixture" noted above for M3, components were varied to produce mixtures with the following consistencies for further testing:

- Soupy
- Low Viscosity
- Medium Viscosity
- Stiff

Table 4.2.4: TB113 Results for Mix M4 (A2+E2)

Formulation	Parts I	by dry we	ight of a	ggregate, g	g	Mix time,	Blot Test,	Coating	Consistency
Formulation	agg, g	cement	water	additive*	emulsion	sec	30 sec	Visual/boiling	Description
1	100	0.0	8.0	0.00	10.5	10	-	-	В
2	100	1.0	8.0	0.25	12.0	70	-	-	В
3	100	1.0	9.0	0.25	13.0	>180	Α	98/95	S
4	100	1.0	9.0	0.25	14.0	>180	Α	98/95	S
5	100	1.0	9.0	0.50	16.0	>180	CW	95/85	MV
6	100	1.5	9.0	0.50	14.0	100	-	1	В
7	100	1.0	10.0	0.50	14.0	>180	CW	95/85	S
8	100	0.5	10.0	0.50	15.0	>180	CW	95/85	MV
9	100	0.5	12.0	0.50	15.0	>180	CW	85/75	LV
10	100	0.5	15.0	0.75	15.0	>180	CW	75/70	S

^{*} Aluminum Sulfate

Consistency	Blot Test
S = Soupy (Brown free liquid, segregating sample)	A = Aggregate and clear water
LV = Low Viscosity (Non segregating easy to mix)	BT= Brown transfer
MV = Moderate Viscosity (Non segregating, moderate resistance to mix)	CW= clear water
St = Stiff (Hard to mix but workable)	
B = Broken (Lumps, non consistent)	

Based on the data contained in Table 4.2.4, the mixture components selected for the AMT for Mix M4 are as follows:

- Aggregate 100 grams
- Cement 1.0%
- Water 9% (Based on the weight of dry aggregate)
- Emulsion 15-16%
- Additive 0.55% Aluminum Sulfate

The resulting mix had the following characteristics:

• Very stable and displayed a wide range of compositions.

- Very quick set.
- Proceeded to clear water and exhibited cohesive form.
- With this emulsion, A2 was not easy to mix and showed poor coating and poor rheology, it also indicated some potential for moisture damage.

In addition to the "base mixture" noted above for M4, components were varied to produce mixtures with the following consistencies for further testing:

- Soupy
- Low Viscosity
- Medium Viscosity
- Stiff

Table 4.2.5: TB113 Results for Mix M5 (A3+E3)

Formulation	Parts b	y dry we	ight of a	ggregate,	g	Mix time,	Blot Test,	Coating	Consistency
Formulation	agg, g	cement	water	additive*	emulsion	sec	30 sec	Visual/boiling	Description
1	100	0.0	10.0	0.0	14.0	>120	Α	100	LV
2	100	0.0	10.0	0.0	12.0	>120	Α	100	LV-MV
3	100	0.0	10.0	0.0	10.0	>120	CW	100	MV
4	100	0.0	8.0	0.0	10.0	>120	CW	100/100	MV
5	100	0.5	10.0	0.0	14.0	>120	Α	100	LV-MV
6	100	0.5	10.0	0.0	12.0	>120	CW	100	MV
7	100	0.5	8.0	0.0	10.0	>120	CW	100/100	MV-St

^{*} Aluminum Sulfate

Consistency	Blot Test
S = Soupy (Brown free liquid, segregating sample)	A = Aggregate and clear water
LV = Low Viscosity (Non segregating easy to mix)	BT= Brown transfer
MV = Moderate Viscosity (Non segregating, moderate resistance to mix)	CW= clear water
St = Stiff (Hard to mix but workable)	
B = Broken (Lumps, non consistent)	

Based on the data contained in Table 4.2.5, the mixture components selected for the AMT for the Mix M5 are as follows:

- Aggregate 100 grams
- Cement 0.0 0.5 %
- Water 9-11% (Based on the weight of dry aggregate)
- Emulsion 8-12%
- Additive 0%

The resulting mix had the following characteristics:

- Very stable and displayed a wide range of compositions
- Proceeded to clear water and exhibited a very cohesive form

Automated Mixing Test (AMT)

As described in Chapter 3, the automated mixing test is used to measure the increase in viscosity with time, by means of a computer-controlled stirrer. From the observed time-viscosity plot, two values of interest are identified: the mix and spreadability indices. The measured mixing times from TB 113 were used as the first cut for initial mixing. Mixing to coating is the mix index and the spreadability is the time for stiffening just prior to setting (see Figure 3.4).

The cohesion values that are reported are the mix and spread indices. Mix components, using different levels of additives and fillers to establish a range of values for control purposes, were evaluated.

This test was repeated for four levels of environmental conditions:

- High temperature (35°C) low humidity (<50 percent)
- High temperature (35°C) high humidity (90 percent)
- Low temperature (10°C) low humidity (<50 percent)
- Low temperature (10°C), high humidity (90 percent)

The specification values may be adjusted and the mixes repeated with both TB 113 and the proposed AMT.

The acceptance criteria will be based on mixes with which the project team has experience and has identified for both TB 113 and the AMT. The test will then be checked with a mix of known performance histories using other materials with which the team and advisory group have significant experience.

The AMT setup considered the following variables:

- Stirrer type
- Mixing container type and size
- Procedure for combination of components

- Stirrer speed
- Mix consistency and type

Initial analysis was based on the observation of mixing of the material compared to observations in TB113 such as, problems with aggregate particles catching in the gap between the bowl and the stirrer, consistency of the mixture and the produced trace. In other words, how the mixtures behaved in the AMT compared to known behavior from the TB113.

During the beginning phases of the evaluation of the AMT, it was important that the proper configurations of the stirring apparatus (blade and shaft) be determined since several are available. The following types were evaluated:

Stirrer type:

The following stirrers were tested in combination with bowl size and type.

- Small Anchor (45 mm diameter)
 - Vendor-IKA Works, Wilmington, NC
 - Catalog/Code Number-R1330 #2022300
- Large Anchor (90 mm diameter)
 - Vendor-Velp Scientifica
 - o Catalog/Code Number-A00001311

These stirrers are noted in Figure 4.1.



Figure 4.1: Large and Small Anchor Stirrers

Features: Produces a tangential flow with high shearing at the outer parts. The produced flow

limits the deposition of solids on the sides of vessel.

Uses: Homogenization at low to medium speed of high solids in liquids of mean to high

viscosity.

• Standard Propeller

Vendor - Velp Scientifica

o Catalog/Code Number-A00001307

This stirrer is noted in Figure 4.2.

Features: Standard stirring shaft produces an axial flow in the vessel from bottom to top with

local shearing.

Uses: Stirring at medium to high speed of high solids, flocculation, mixing of thickening

agents, sludges, etc.



Figure 4.2: Standard Propeller Stirrer

Paddle Stirrer

- Vendor Velp Scientifica.
- o Catalog/Code Number-A00001308

This stirrer is noted in Figure 4.3.

Features: Produces a tangential flow with a limited turbulence and a gentle mixing.

Uses: Stirring at low to medium speed when a good heat exchange among the mixed products is required.



Figure 4.3: Standard Paddle Stirrer

• Turbine

- o Vendor Velp Scientifica.
- Catalog/Code Number-A00001309

This stirrer is noted in Figure 4.4.

Features: Produces a radial flow with a movement of products from top and from bottom with a strong turbulence and shearing.

Uses: Use at medium to high speed for dissolving products or breaking particles.



Figure 4.4: Standard Turbine Stirrer

Mixing Containers type and size:

a. Beakers

- 1 Liter Glass with flat base
- 1 Liter Plastic with concave base

b. Stainless Steel Bowls

- 20cm diameter by 17.5 cm high Large stainless steel Hobart Bowl from N50 mixer
- 7 cm diameter by 10 cm high Large stainless steel with round bottom
- 1.5 Quarts SS Bowl, #1044 supplied by Norpro, Everett, WA
- 7cm tall with a 5 cm radius and round bottom Small stainless steel Bowl, # 99637 supplied by Vollrath.

These bowls are noted in Figure 4.5.



Figure 4.5: Stainless Steel Bowls

Other

Other containers were evaluated including pitcher type and flat- bottomed pans. These quickly were abandoned, as they were not acceptable because their particular shape did not allow the material to achieve a homogeneous state while mixing. It was noted that containers with semi-rounded bottom edges allowed the material to "fold" better.

Procedure for Combination of Components:

The components were combined in various ways in an attempt to obtain an optimum system. The methodology in the AMT is to determine the amount of each of component materials using TB 113, placing them in the mixing bowl, and using the AMT to pre-blend them.

Stirrer Speed:

Stirrer speeds were varied to create mixing that did not seclude material on the sides of the bowl. TB113 consistency criteria were used to make this determination.

A series of speeds were varied to arrive at the most effective to combine the ingredients without "splashing" them out of the bowls. The speeds were 50, 60, 200, 500, and 1000 revolutions per minute (rpm). The mixing speed recommended for the proposed test method was 50 rpm.

Mix Consistency and Type:

Mixes that were classified as Moderate Viscosity (MV), Stiff (St), and Low Viscosity (LV) were tested to evaluate mixing torque and combinations of consistencies to ascertain if the mixing torque range could be used as a rheological classification. The results indicated clearly that the mixing torque was dependant on the rate of cohesion build up and presumably the reaction rate between the aggregate and the emulsion type. That is, microsurfacing systems and slurry quick set systems could be differentiated by mixing torque and its change with time.

AMT Results

A) Preliminary Container/Stirrer/Speed Combination:

A single mix, mix M2, was selected to determine the best container/stirrer combination as it was determined to be the most stable mix from TB113. In addition, M2 exhibited good consistency (MV) and an acceptable mixing time between 3 to 5 minutes. The stirrer type was matched with the container size to provide some separation between the sides of the stirrer and the walls of the container. The purpose of this was to accommodate the largest stone in the mix. This was checked and assessed by observing the mix and its consistency. The mix speed was varied and the mix characteristics were noted. The selection of the container, stirrer, and speed was based on the results that are contained in Table 4.3. The proposed AMT configuration is shown in Figure 4.6. The results showed that the best combination for the AMT setup is as follows:

- Small stainless steel bowl
- Standard propeller stirrer

50 rpm mixing speed

This configuration generated a mix that was complete with little to no hang up material on the sides of the cup rated as "Good Mixing" (GM). An even mixing trace for the configuration is shown in Figure 4.7. The sudden spikes in the graph are due to aggregate caught in the gap between the bowl and the stirrer. The torque is noted on the vertical axis and time in the horizontal axis. In this case, an increase in torque from 8kg-cm to 10kg-cm was observed.



Figure 4.6: AMT Configuration of Standard Propeller and Small Stainless Steel Bowl.

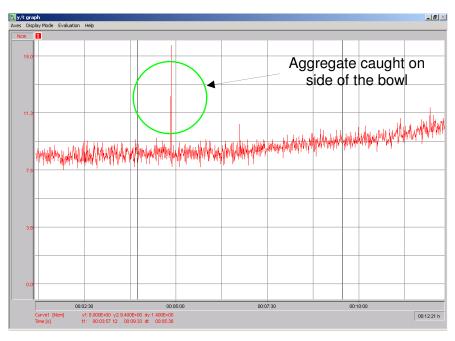


Figure 4.7: Screen Shot of AMT Using Small Stainless Steel Bowl and Standard Propeller Configuration at 50 rpm for M2

Table 4.3: Combinations of Stirrers and Containers for mix M2

	Cup Tupo		
Stirrer	Cup Type	Speed rpm	Mixing Result
Small Anchor	400ml Beaker Glass	50	Poor Mixing (PM)
Small Anchor	400ml Beaker Glass	60	Poor Mixing (PM)
Small Anchor	400ml Beaker Glass	200	Poor Mixing (PM)
Small Anchor	400ml Beaker Glass	500	Broken
Small Anchor	400ml Beaker Glass	1000	Broken
Large Anchor	1 L Glass	50	Adequate Mixing (AM)
Large Anchor	1 L Glass	60	Adequate Mixing (AM)
Large Anchor	1 L Glass	200	Adequate Mixing (AM)
Large Anchor	1 L Glass	500	Broken
Large Anchor	1 L Glass	1000	Broken
Large Anchor	1 L Plastic	50	Poor Mixing (PM)
Large Anchor	1 L Plastic	60	Poor Mixing (PM)
Large Anchor	1 L Plastic	200	Poor Mixing (PM)
Large Anchor	1 L Plastic	500	Broken
Large Anchor	1 L Plastic	1000	Broken
Large Anchor	Hobart Bowl	50	Poor Mixing (PM)
Large Anchor	Hobart Bowl	60	Poor Mixing (PM)
Large Anchor	Hobart Bowl	200	Poor Mixing (PM)
Large Anchor	Hobart Bowl	500	Adequate Mixing (AM)
Large Anchor	Hobart Bowl	1000	Broken
Large Anchor	Large SS Bowl	50	Good Mixing (GM)
Large Anchor	Large SS Bowl	60	Good Mixing (GM)
Large Anchor	Large SS Bowl	200	Adequate Mixing (AM)
Large Anchor	Large SS Bowl	500	Adequate Mixing (AM)
Large Anchor	Large SS Bowl	1000	Adequate Mixing (AM)
Large Anchor	Other	50	Poor Mixing (PM)
Large Anchor	Other	60	Poor Mixing (PM)
Large Anchor	Other	200	Poor Mixing (PM)
Large Anchor	Other	500	Broken
Large Anchor	Other	1000	Broken
Standard Propeller	Small SS Bowl	50	Good Mixing (GM)
Standard Propeller	Small SS Bowl	60	Good Mixing (GM)
Standard Propeller	Small SS Bowl	200	Good Mixing (GM)
Standard Propeller	Small SS Bowl	500	Broken
Standard Propeller	Small SS Bowl	1000	Broken
Paddle	Large SS Bowl	50	Poor Mixing (PM)
Paddle	Large SS Bowl	60	Poor Mixing (PM)
Paddle	Large SS Bowl	200	Poor Mixing (PM)PM
Paddle	Large SS Bowl	500	Broken
Paddle	Large SS Bowl	1000	Broken
Turbine	· ·		
	Small SS Bowl	50	Poor Mixing (PM) Poor Mixing (PM)
Turbine	Small SS Bowl	60	
Turbine	Small SS Bowl	200	Poor Mixing (PM)
Turbine	Small SS Bowl	500	Broken
Turbine	Small SS Bowl	1000	Broken
Large Anchor	Other	50	Poor Mixing (PM)
Large Anchor	Other	60	Poor Mixing (PM)
Large Anchor	Other	200	Poor Mixing (PM)
Large Anchor	Other	500	Broken
Large Anchor	Other	1000	Broken

The shape of the traces for different configurations of mix container and stirrer did vary. In addition, for some configurations, differences in torque were observed. Some configurations

produced poor mixing and hang up on the sides of the mixing containers. As a result, the mix tends to break and the mixer had less material to turn. The endpoint of the mixing was characterized by a decrease in torque (torque fall off) due to the mixer effectively turning in the liquid left after the mixture broke. These tests were rejected and classified as poor mixing. The best results were obtained with the combination of the small stainless steel bowl and the standard propeller. Part of this testing was repeated with mix M4 and the results were consistent with the previous findings and are noted in Table 4.4. An interesting observation was that the mixes that contained the emulsion E2, continued to mix in excess of 10 minutes but broke as soon as the mixer was turned off. This is a phenomenon often observed in the field and is a function of the film formation process created by aggregate/emulsifier interaction. The mechanical action appears to prevent coalescence by disrupting film formation; when the mixer was turned off, coalescence proceeded swiftly, and the cohesion increased as a result. In CQS type systems, the films form during agitation and cohesion build up is more gradual. As this is a function of interaction of two materials it depends on both. As it is a function of reactivity, it is also dependent on the conditions of temperature and as water will interfere with coalescence and film formation, it is dependant on humidity and total water content.

The two configurations that produced best mixing results were: the standard propeller with the small stainless steel bowl, and the large anchor stirrer with the large stainless steel bowl.

Table 4.4: Mix M4 Stirrers and Mixing Containers Combinations and Results

Stirrer	Cup Type	Speed rpm	Mixing Result
Large Anchor	Large SS Bowl	50	Adequate Mixing (AM)
Large Anchor	Large SS Bowl	60	Adequate Mixing (AM)
Standard Propeller	Small SS Bowl	50	Good Mixing (GM)
Standard Propeller	Small SS Bowl	60	Good Mixing (GM)

The characteristic mixing trace of the large stainless steel bowl and large anchor configuration is shown in Figure 4.8. This trace indicates that the system did not mix well, and as the material broke, the segregation was of liquid to the center of the bowl. This trace was not indicative of mix M4 actual behavior.

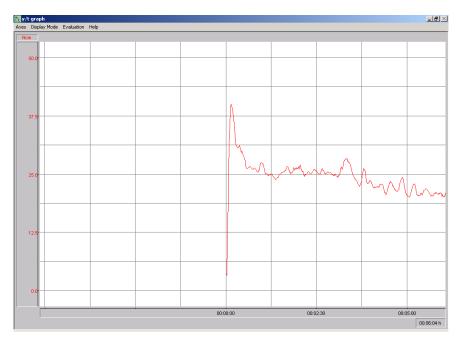


Figure 4.8: Mix M4 with Large Anchor Stirrer and Large Stainless Steel Bowl

For the standard propeller and small stainless steel bowl configuration, and using a stirrer speed of 50 rpm, the mixing was improved. A close-up of the standard propeller and small stainless steel bowl is shown in Figure 4.9. A homogeneous state was achieved for the mix. An increase in torque with time was also the result of the configuration and is shown in Figure 4.10.



Figure 4.9: AMT Standard Propeller and Small Stainless Steel Bowl Close Up

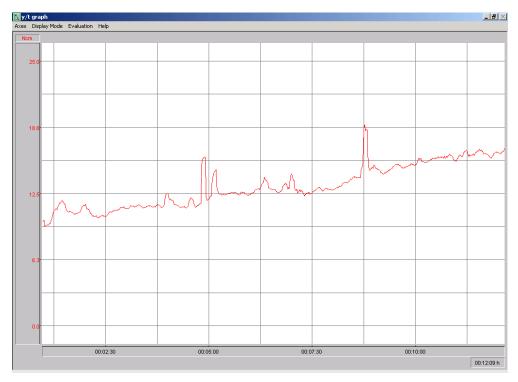


Figure 4.10: Mix M4 Trace with Standard Propeller and Small Stainless Steel Bowl at 50 rpm

B) Effect of Mixing Procedure:

The first mixing procedure attempted was combining the dry aggregate, cement, additives, and water in the mixing bowl. The emulsion was added last. At this point, the AMT was started. This procedure caused a significant increase in "noise" in the AMT traces and almost no increase in torque. This noise was a result of the materials initial resistance to mix. The trace for this mixing procedure is shown in Figure 4.11.

The second mixing procedure consisted in "pre-mixing" the ingredients in the bowl; emulsion last. The results indicated less initial mixing resistance and an increase in torque with time. Figure 4.12 shows the trace of the pre-mixed materials. Based on these observations, the mixing procedure steps were determined.

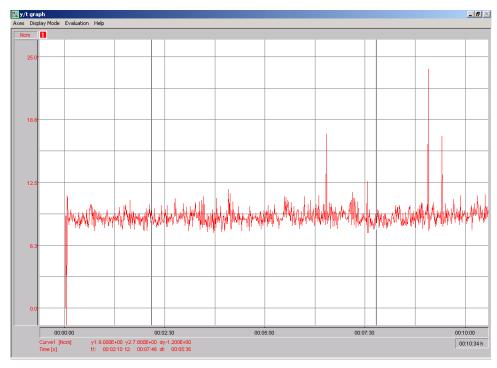


Figure 4.11: AMT All Ingredients Combined in the Mixing Bowl

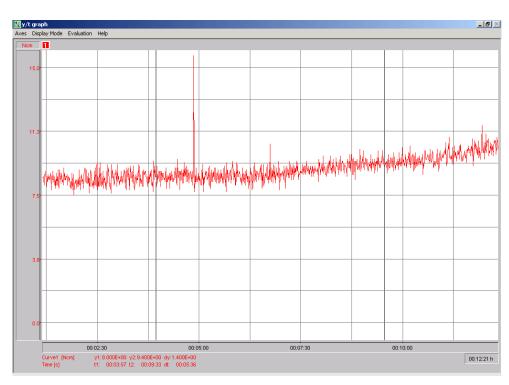


Figure 4.12: AMT Pre-Mixed Ingredients in the Mixing Bowl

The recommended mixing procedure for the AMT is the following:

- 1. Choose mix components from existing information or TB113 and determine the percentage of each component based on the weight of dry aggregate.
- 2. Weigh 300g of dry aggregate into the small stainless steel bowl.
- 3. Add Cement or other dry additive and mix thoroughly.
- 4. Add water and mix thoroughly.
- 5. Add liquid additive and mix thoroughly.
- Add emulsion and mix quickly for 5 to 10 seconds.
- Immediately after mixing the emulsion, place the bowl in the AMT machine, clamp, and lower stirrer to within 1-2 mm from the bottom of the bowl and assure that the stirrer is centered.
- 8. Turn on AMT unit and mix 5 seconds.
- 9. Set test speed to 50 rpm.
- 10. Measure trace for 10 minutes.
- 11. Record steady state torque as the <u>Mix Index</u>, record time where steady increase of torque begins as the <u>Mix Time</u>.
- 12. Record time where torque reaches 12 N-cm as the Spread Time.
- 13. Record time when mix is broken by observation.

C) Effect of System Type:

To evaluate the effectiveness of the recommended AMT procedure, systems with E1 and E2 emulsion were measured. Systems with three different consistencies, Soupy (S) or Low Viscosity (LV), Stiff (St), and Moderate Viscosity (MV) were evaluated and observations noted.

Mix M4 was chosen as the system with Soupy consistency. In Figure 4.13, the mixing Torque was observed to be 6 to 7 N-cm. It was also noted that the mix M4 did not break until after the AMT was stopped.

For the stiff system, Mix M1, the mixing torque was recorded to be 9 to10 N-cm and the mix time about 3.5 minutes. At this point in time, the torque was noticeably beginning to increase. The trace is shown in Figure 4.14.

For the system M2 previously identified as a good mixing system, with Moderate (MV) consistency, the mixing torque was 8 to 9 N-cm. The mix time was close to 7 minutes. However, mix M2 never reached the maximum spread torque of 12 N-cm before14 minutes. The system stiffened only after mixing ceased. The trace of mix M2 is shown in Figure 4.15.

Table 4.5 shows the summary of the ranges in torque for the three different systems with Soupy, Stiff, and Moderate consistencies.

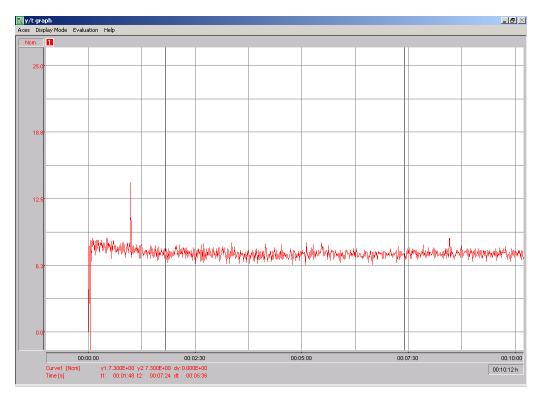


Figure 4.13: AMT Trace for Mix M4, Soupy (S) / LV System

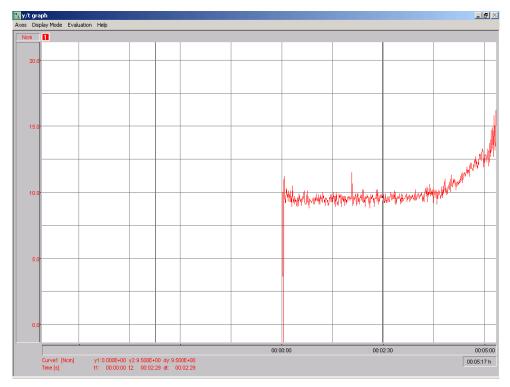


Figure 4.14: AMT Trace for Mix M1, Stiff (St) System

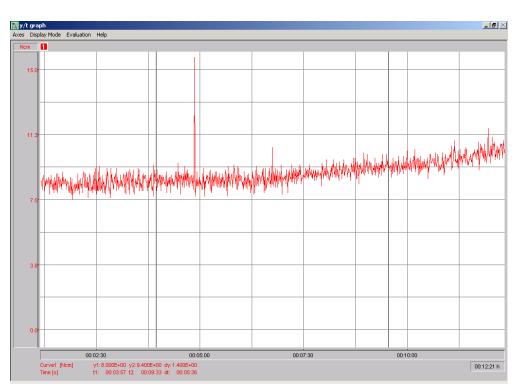


Figure 4.15: AMT Trace for Mix M2, Moderate (MV) System

Table 4.5: Preliminary Evaluation of Consistency and Mixing Torque

System	Consistency	Mixing Torque, N-cm	Mixing Time, min	Spread Time, min
M1	Stiff (St)	9 – 10	3.5	4.9
M2	Moderate (MV)	8 – 9	7	>10
M3	Soupy (S) / LV	6 – 7	>10	>10

Conclusions:

The mix procedure can distinguish between very fast and fast setting systems. The procedure can show the differences in mixing and spread time for different systems. It also shows mixing torque correlation with the mix characteristics of TB113.

4.2.2 Development of the Automated Cohesion Test (ACT)

The existing ISSA test method for cohesion, TB 139, uses a hand held torque wrench to apply a load to a test specimen 6 mm or 10 mm in diameter depending on the top size of the aggregate. Torque measurements are made at intervals of 30, 60, 90, 150, 210, and 270 minutes after casting the specimens.

The major difficulty with this procedure is that the application of torque is very operator dependent. To overcome this problem, the project team contracted with Temple Systems, Inc. of Dayton, Ohio to develop an automated device to perform this test. The device is connected to a computer and is controlled by software that lowers a pressure foot on the test specimen. The operator specifies the amount of rotation of the foot at the time intervals specified. The rotation can be set from 45 to 360 degrees. During rotation, the device transmits torque values to the computer. When complete, the torque measurements are graphically displayed.

The "first article" design of the Automated Cohesion Test device has been developed by Temple Systems Lab of Dayton, Ohio and it is shown in Figure 4.16. Testing on sandpaper was completed to assure that the device functioned properly. The device was then sent to MACTEC's laboratory in Phoenix, Arizona, to complete the testing matrix.



Figure 4.16: Automated Cohesion Test – Under Development

Limited comparison testing with both the automated and the conventional cohesion testers was carried out by Temple Systems and MACTEC. The results are presented in Figures 4.17 and 4.18.

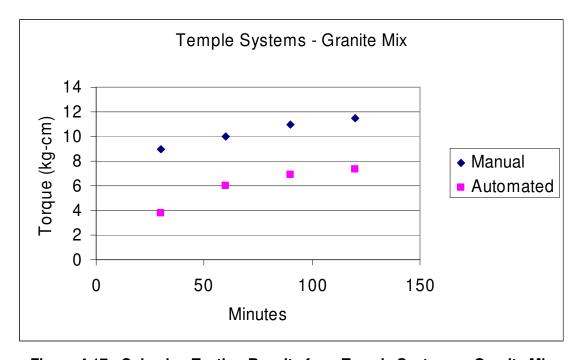


Figure 4.17: Cohesion Testing Results from Temple Systems – Granite Mix

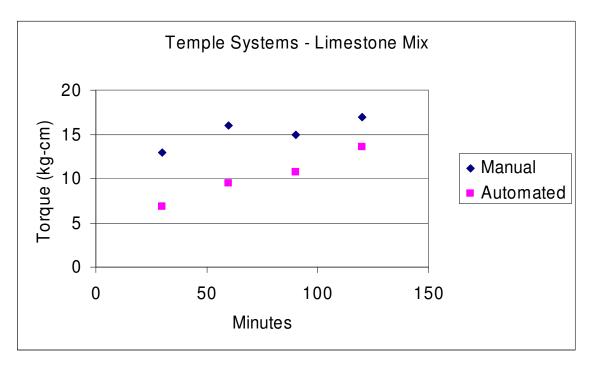


Figure 4.18: Cohesion Testing Results from Temple Systems – Limestone Mix

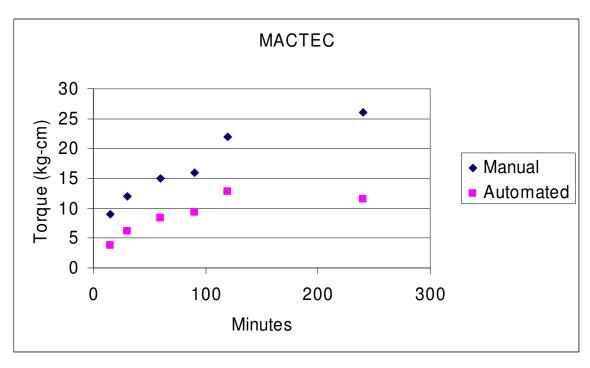


Figure 4.19: Testing Results from MACTEC

As illustrated in Figures 4.17 and 4.18, the ACT results are consistently lower than the conventional (manual) wet cohesion results. The possibility of correcting the ACT results by a correction factor or model was then investigated. This was done by pooling the data from Temple Systems and MACTEC into a single data set and plotting "automated" versus "manual" results, as illustrated in Figure 4.19.

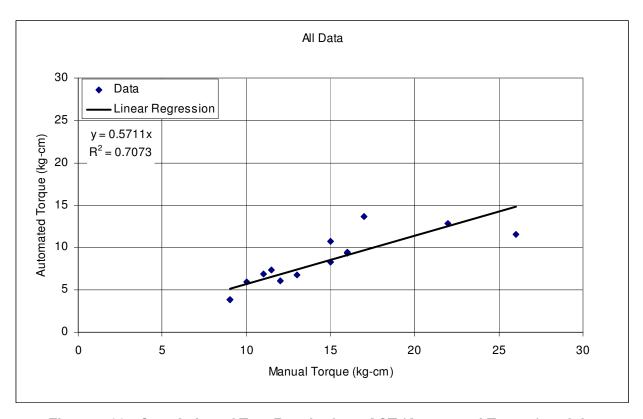


Figure 4.20: Correlation of Test Results from ACT (Automated Torque) and the Conventional Wet Cohesion Tester (Manual Torque)

As illustrated in Figure 4.20, there is a good correlation between the two tests ($R^2 = 0.7$). A correction factor of 1.75 (=1/0.5711) can be used to bring the Automated values within the range of values obtained from the conventional wet cohesion test. A plot of corrected values versus the conventional ones is shown in Figure 4.21.

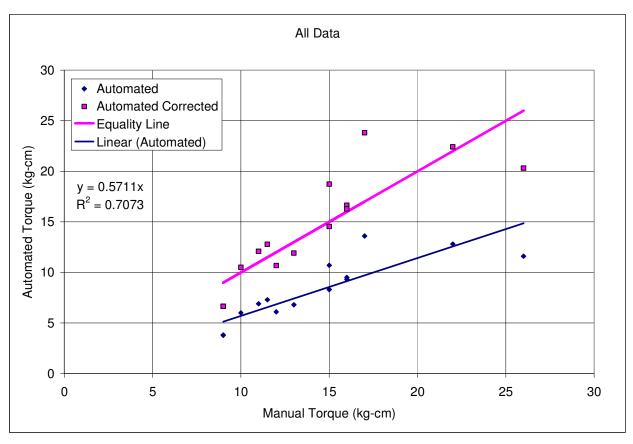


Figure 4.21: Correction of Test Results from ACT.

As illustrated in Figure 4.21, the 1.75 correction factor can be used to bring the ACT results within the range of values normally measured with the conventional wet cohesion test.

Another experiment run at the MACTEC laboratory in Phoenix consisted of calibration tests with the two devices on 220 grit sand paper. A number of 10 measurements were taken with each device. The average and standard deviation of the test results are given in Table 4.6

Table 4.6: Results of Calibration Tests on 220 Grit Sand Paper

Statistic	Conventional Wet Cohesion Torque (kg-cm)	Automated Cohesion Torque (kg-cm)	
Average	19.90	11.22	
Standard Deviation	0.99	1.14	

Note that the ratio of the two averages (i.e. 19.9/11.22) equals 1.77, which is very close to the correction factor of 1.75 obtained from the tests on slurry systems.

4.2.3 Development of the Cohesion-Abrasion Test (CAT)

The Cohesion-Abrasion Test is a modified version of the Wet Track Abrasion Test (WTAT), ISSA TB 100. A two-wheel fixture is used instead of the standard abrasion head. As a result of this modification, the abrasive action is less severe and the test can be used to evaluate system cohesion buildup during curing and before opening to traffic as well as abrasion resistance after opening to traffic or on oven cured specimens. The test can be performed on test samples similar to those for the wet cohesion test.

It was also hoped that the test could be used to differentiate between slurry quick set, microsurfacing, and slow set slurry. For specification purposes, ranges of loss would be more appropriate than minimum or maximum losses alone.

The first modification made to the standard Wet Track Abrasion Test (TB 100) setup was the use of a N50 Hobart unit with the wheel attachment; this has a smaller abrasion area so the loss levels needed to be reestablished when compared to the existing TB 100 test. Figure 4.22 shows the CAT with the wheel attachment during testing.

The following variables were identified and evaluated during the development phase:

- 1. Effect of test specimen base support type (Roofing Felt/Steel/Aluminum)
- 2. Effect of assessment method for aggregate loss (Wet Loss/Aggregate Loss Recovery/Dry Loss)
- 3. Effect of tack coat
- 4. Effect of soaking samples in relation to cure time
- 5. Stripping effects in aggregates at different test conditions
- 6. Effect of system on aggregate and emulsion behavior
- 7. Compaction by hand surface consolidation (Hand Roller)



Figure 4.22: Cohesion Abrasion Test Apparatus (CAT)

1. Effect of Test Specimen Base Support

Three base supports were evaluated: the first one was a 30 lb roofing felt, the second was a stainless steel plate 2mm thick, and the third was an aluminum plate 2mm thick. The effect that these support bases had on the test results was examined for two mixes, M2 and M4. Results and recommendations are discussed together with the assessment method for aggregate loss.

2. Effect of Assessment Method for Aggregate Loss

The assessment of material loss after abrasion was done as follows:

- Wet Loss Method The initial weight of the specimen and support base were recorded before abrasion. After the abrasion test, specimen and plate were patted dry with paper towels. This resulting weight was the final weight and the difference was recorded as the loss.
- Aggregate Loss Recovery Method The initial weight of the specimen and support base were recorded before abrasion. During and after abrasion, all loose aggregate was recovered. The weight of the recovered aggregate was subtracted from the initial weight of the specimen and support base to obtain the final weight.

 Dry Loss Method – Two identical specimens were prepared. One specimen and support base was abraded and the loose material was removed. The second specimen and support base were not subjected to the abrasion test. Both specimens were then oven-dried over night. The loss was determined as a percentage between the abraded specimen and the un-tested specimen.

The general results for the support bases and the assessment method were noted as follows:

The felt support base absorbs water and is difficult to handle and to pat-dry with paper towels. It tends to loose more material as it flexes, therefore, it produces a wider scatter of results. The aluminum and steel support bases were easy to use and handle. The results using these metal bases were observed to be more repeatable.

The Dry Loss Method and the Wet Loss Method gave the most reproducible results. The Aggregate Loss Recovery Method proved very difficult to do and larger variations of the results were observed.

In order to evaluate the effects that the base support and the assessment method have, mix M2 was used. The formulation of mix M2 was previously studied and consisted of the following proportions:

- 100 g aggregate
- 1.5 g cement
- 8 g water
- 0.25 g additive
- 1.3 g emulsion

The test specimens were cured for 30 min, 60 min, and 180 minutes before testing. Duplicate tests were performed for each of the assessment methods and base supports, except for the Aluminum base, for which only one test was performed. The results are summarized in Table 4.7. The decrease in abrasion loss with time is illustrated in Figures 4.23 and 4.24.

Table 4.7: Test Specimen Bases and Assessment Methods for Mix M2

Curing Time, (min)	Support Base	Wet Loss Method (g)	Aggregate Loss Recovery Method (g)	Loss on dry basis* (%)
30	Felt	290/320	265/280	29/31
30	Steel	248/225	210/195	24.5/23.5
30	Aluminum	235	195	23
60	Felt	162/220	199/175	16.4/17.5
60	Steel	94/85	85/75	9.5/10.1
60	Aluminum	87	80	8.9
180	Felt	25/35	19/28	2.9/3.5
180	Steel	23/19	23/18	2.4/2.1
180	Aluminum	25	21	2.5

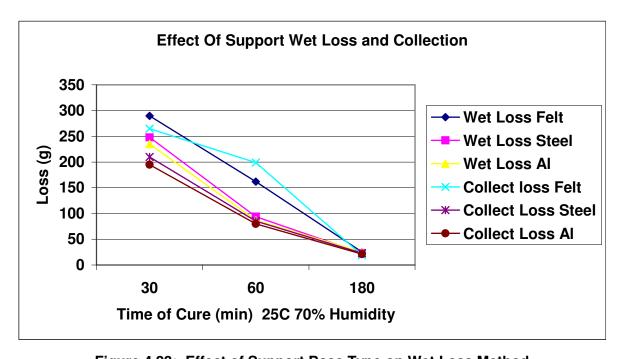


Figure 4.23: Effect of Support Base Type on Wet Loss Method

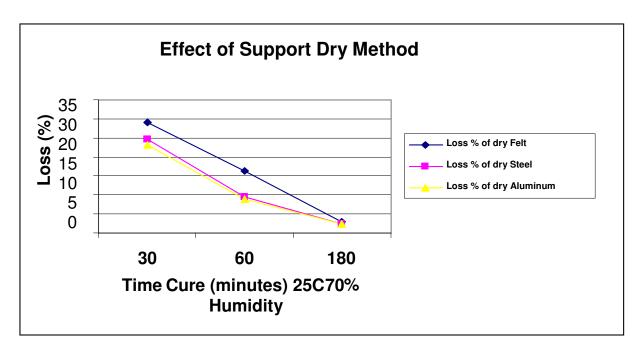


Figure 4.24: Effect of Support Base Type on Dry Loss Method

It was concluded that metal (Steel or Aluminum) support bases are easier to handle and create less aggregate loss. The use of a metal support base is therefore recommended. The Aluminum base is preferred because it is lighter and more resistant to corrosion.

The recommended assessment method is the Wet Loss Method. Even though both, the Wet Loss Method and the Dry Loss Method had reproducible results, the Wet Loss Method was preferred since immediate results can be obtained. A comparison of the loss measured with the two methods shown in Figure 4.25.

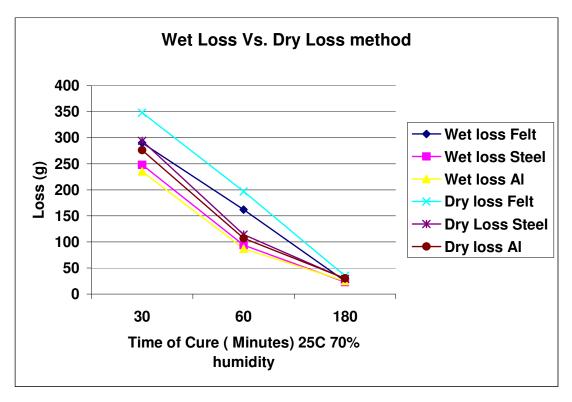


Figure 4.25: Comparison of Losses as Determined by Wet and Dry Loss Methods

Aggregate and Emulsion Effects

The Aluminum base support was used and the tests repeated with two mixes, Mix MA and Mix MB. These mixes were cured at 25C and 70% humidity. The mix proportions were as follows:

Mix MA

- 100 grams of aggregate
- 1 gram of cement
- 9 grams of water
- 0.5 grams of additive
- 1.5 grams of emulsion

Mix MB

- 100 grams of aggregate
- 0.5 grams of cement
- 10 grams of water
- 0.5 grams of additive
- 1.5 grams of emulsion

The differences in the samples were the amount of water and cement. Test results are summarized in Table 4.8. The decrease in loss with time is shown in Figures 4.26 and 4.27.

Table 4.8: CAT Results for Mix MA and MB

Mix	Pre-treat Compaction	Time of cure (min)	Loss wet (g)	Loss Oven dry (g) %
А	N	30	265/250	26.1
	N	60	165/170	12.6
	N	180	77/72	6.4
Α	Y	30	-	-
	Y	60	145/155	-
	Y	180	-	-
В	N	30	433.9/455	28.8
	N	60	275/285	19.2
	N	180	239.5/225	15.9
В	Y	30	-	
	Y	60	220	-
	Y	180	-	

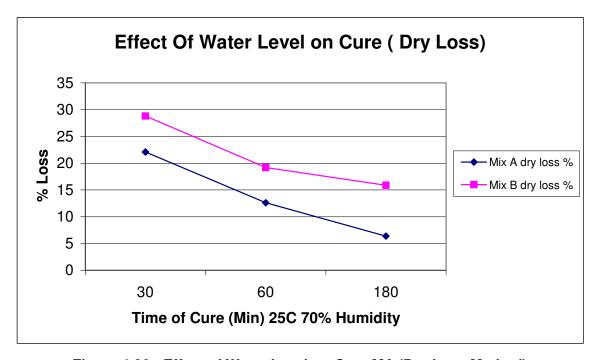


Figure 4.26: Effect of Water Level on Cure MA (Dry Loss Method)

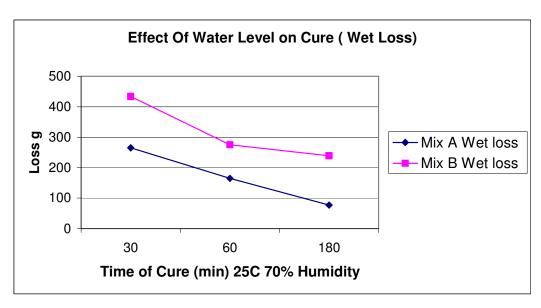


Figure 4.27: Effect of Water Level on Cure MA (Wet Loss Method)

Compaction was conducted on selected samples and accomplished by exerting pressure on to the sample surface with a roller and mopping up any water with paper towels of high absorbency.



Figure 4.28: CAT Hand Roller

Both systems were correctly defined by this test as quick set; the aggregate effect was clearly distinguished. Compaction did consolidate the surface to some extent but an analysis of the date indicates that there is no significant difference between the compacted and non-compacted specimens and as a result compaction is not recommended. This is illustrated in Figure 4.29.

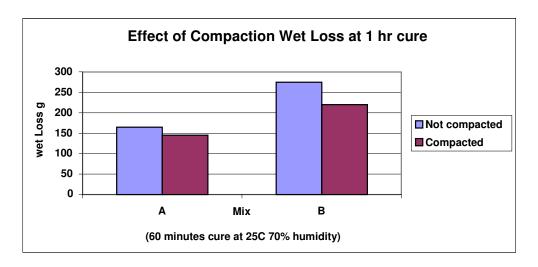


Figure 4.29: Effect of Compaction on Mix MA (Wet Loss Method)

4.2.4 Effect of Tack Coat

Tack coat was applied on the metal base using a brush. The base plate was covered with a thin, even coat of emulsion. The tack coat was allowed to dry to the touch. As illustrated in Figure 4.30, the tack seemed to reduce losses perhaps by holding the sample firmly and preventing shear at the base.

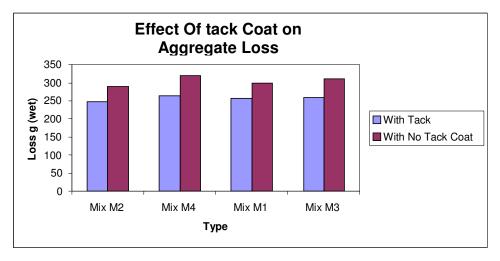


Figure 4.30: Effect of Tack Coat on Mix MA

4.2.5 High Traffic and Rut Resistant System CAT Results

An exercise to evaluate the CAT system and its effects on high traffic systems was conducted.

The procedure was repeated with the mixes M1 and M3 with optimum mix components established from TB113 and the AMT. The results are illustrated in Table 4.9 and Figure 4.31.

Mix M1

- 100 grams of aggregate
- 1 gram of cement
- 8 grams of water
- 0.5 grams of additive
- 14 grams of emulsion

Table 4.9: Wet Loss Method Results

Time (min)	Wet Loss M1 (g)	Wet LossM3 (g)	Dry Loss M1 (%)	Dry Loss M3 (%)
30	256	236	19	19.4
60	49	64.4	4.2	5.1
180	14	10	1.8	1.6
300	6.3* (1)	2*(<1)	0.8*(0)	0.6*(0)

^{*1} hr soak

These results are plotted below. The M1 emulsion system set faster but the M3 aggregate still had the tendency to strip at short cure times. Samples were also cured at 5 hrs, soaked for 1 hour, and tested as shown (note that loss after 5 hours cure are shown in brackets above).

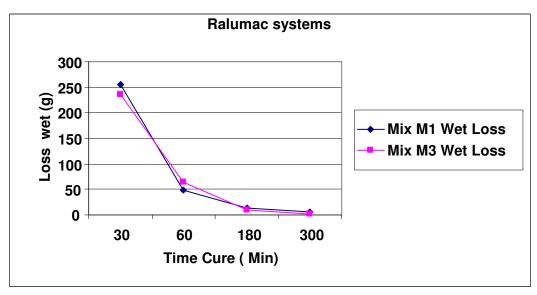


Figure 4.31: Losses with Microsurfacing Systems

The results were compared to the E-2 systems for Table Mountain and Lopke (M2 and M4) and are illustrated in Figure 4.32.

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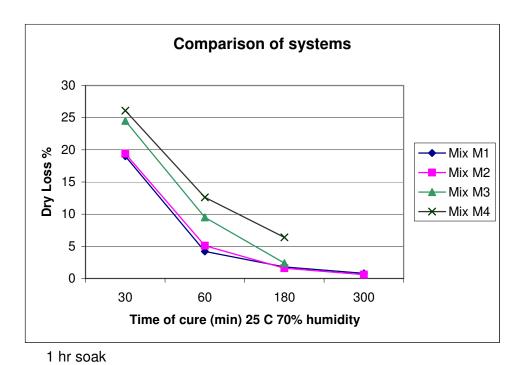


Figure 4.32: Comparison of Different Systems Using CAT

The test appears to distinguish between system types at 25C and 70% humidity.

The existing wet track abrasion test, TB100 was measured for all systems and compared to the CAT test which is noted in Table 4.10.

Table 4.10: TB 100 Test Results

System	Loss WTAT /1 Hour Soak (g/cm ²)	Loss 5 hr cure*dry 1 hour soak (g/cm²)
M2	0.8	0.5
M4	1.02	0.9
M1	0.8	0.4
M3	1.1	0.4

^{* 25}C 70% humidity

The data indicates that the abrasion loss is similar for the wheels in the CAT tests compared to WTAT for the comparable level of cure and soaking, since both show low losses. For long term abrasion and determination of the base binder level it is suggested that the range of soak periods are the same as are used for CAT test. The WTAT will be needed to determine the long term performance properties of the S3 mixes.

4.3 LABORATORY TEST METHODS EVALUATION

4.3.1 Evaluation of Automated Mixing Test (AMT)

The proposed AMT test method covers measurement of constructability of slurry surfacing materials once the basic ratios of the components have been established. By automatic and constant recording of the complete torque-measurement-curve, the mixing curve indicates each variation during the breaking process—the process where the mixture changes from a homogenous flowing consistency to a stiff non-flowing consistency.

The AMT procedure was developed with the intention of providing additional information about the breaking process for a particular mix system after initial mix proportions were established by using TB 113 and to eliminate operator variability.

Differences between proposed and current test methods:

- In TB113, the curing condition for humidity is not specified.
- The current hand mixing method allowed the use of various mixing bowls or containers, and mixing stirrers.
- The current hand mixing method required a specified rpm during the manual mixing, but that would vary from operator to operator.
- The original hand mixing method did not specify any details to the direction of rotation or depth of the stirrer into the mixture during the mixing process, so that would vary from technician to technician.
- In TB113, mix proportions were adjusted to meet the minimum mixing times in the project specifications. This tended to produce a mix with a higher viscosity than the viscosity of the system used during placement in the field.

Advantages of the proposed test method:

The AMT method standardizes testing conditions for humidity, mixing bowl, stirrer, mixing rotations and mixing rate. In the current TB113 procedure, these variables greatly influence the final result and it varies from technician to technician and laboratory to laboratory.

In addition, another advantage is that this method evaluates the mix system for the type of break the system has by measuring the mixing torque, spread time and maximum torque.

Correlation between the proposed and current methods:

In the original hand mixing method per TB113, the mix proportions were adjusted to determine mixing times relatively close to the minimum mix time requirements: 3 minutes for slurry seal systems and 2 minutes for micro-surfacing systems. When the minimum proportions were used for the AMT, as determined by using TB 113, predictably the mixes would be changing much more quickly and recorded as such during the AMT evaluation.

In both test methods (proposed and current), when there were more total liquids in the systems, the viscosities were lower. In both test methods, mix systems with higher total liquids will deliver very extended mixing times.

Suitability of the proposed test method:

The equipment as developed still requires that the operator has a certain level of experience in order to set up and run the test in a short period of time.

As developed, the equipment needs to be modified to accurately control mixing temperatures other than 25 °C and mixing humidity above 50%.

Another challenge is the operation of the IKA software. This software was originally developed for use with multiple mixers, mediums and applications.

Additional research needed for this test method:

All the mixes used during the evaluation of the AMT were mixes where the aggregate was larger than a Type 2 aggregate. More evaluations should be performed on different aggregate sizes.

The test method does require that the laboratory technician have experience in preparing the mix and setting the mixture into the testing equipment. Somehow making that process mechanical would decrease the amount of experience a technician is required to have to perform the AMT method and decrease the amount of error when the stirrer is not properly placed into the mixture.

An environmental chamber that won't affect the motor of the mixer or the shaft of the mixing tool needs to be developed for evaluating mix systems for temperatures at 15°C or 35°C and at higher humidity conditions.

Developing a specific software program for slurry system applications as it relates to the AMT method would make the test method easier to use from one laboratory to another.

4.3.2 Evaluation of Cohesion-Abrasion Test (CAT)

The proposed CAT test method covers the measurement of the wearing qualities of slurry seal and micro-surfacing mixture systems under wet abrasion conditions and early cohesion properties at different levels of cure.

Currently, test practices for abrasion are not performed on uncured mix specimens. The cohesion abrasion test is appropriate for measuring early cohesion build up as the mixture cures under various curing conditions. If high losses during initial curing of the mix are observed, generally this indicates that the mix will have a poor performance.

Differences between proposed and current test methods:

- In the original wet track abrasion test per TB100, the test is performed on the aggregate after it has been scalped over the #4 sieve.
- In the proposed method, testing is performed on the bulk sample that has 100% passing the 3/8" sieve.

- In the original wet track abrasion test per TB100, the test specimens are aged in a 60 ℃ oven before initiating moisture conditioning.
- In the proposed method, testing is performed on specimens that are cured at specified temperatures, representing ambient field conditions at 15 °C, 25 °C, or 35 °C. Additionally, this is done at varying ambient field moisture conditions at 50% or 90% humidity.
- In the original wet track abrasion test per TB100, the test specimens are not compacted before curing.
- In the proposed method, one set of test specimens are compacted before curing and another set of test specimens are not compacted before curing to note the difference.
- In the original wet track abrasion test per TB100, the abrasion head rotates a fixed rubber hose along the surface of the sample.
- In the proposed method, the abrasion head rotates a set of two free-spinning rubber wheels along the surface of the sample.
- In the original wet track abrasion test per TB100, the test specimen loss is determined from the original weight of an oven cured test specimen after it has been abraded, and fines rinsed, and the remaining test specimen is oven dried.
- In the proposed method, the test specimen loss is determined from the final weight of the test specimen after it has been abraded, and the fines rinsed, without oven drying.

Advantages of the proposed test method:

The most noticeable advantage of this method is that the evaluation is performed on a complete aggregate gradation. None of the material is scalped as specified in the current method so it represents the mixture as it will be used in the field.

The other advantage of this method is that it tests the mix system as it begins to cure under various conditions. This will provide an indication of the behavior of the mix system at different ambient conditions in the field. This is a reliable indicator of performance of the mix system representing the early curing and cohesion build up of a mix.

Correlation between the proposed and current methods:

In the original wet track abrasion test per TB100, and the proposed test method, the test specimen loss decreases as the emulsion content increases.

Suitability of the proposed method:

The cohesion abrasion test method includes equipment that is easy to operate and the method is simple to follow and perform.

Currently, test practices for abrasion are not performed on uncured mix specimens. The cohesion abrasion test method is appropriate for measuring early cohesion build up as the mixture cures under various curing conditions. If we see high losses during initial curing of the mix, we can expect to predict a problematic mix.

Additional research needed:

The cohesion abrasion test method would benefit from field validation of various mixes in predetermined conditions and test sections.

Potentially, this test method could be used to measure early cohesion build up and predict the early performance of the mix shortly after placement. If an on-site laboratory were available, this test method may be used to measure early curing in the field to validate the recently placed mix. The limitation, at this time, is that there has not been a method mutually accepted by industry and agencies that successfully captures a representative sample of the mixture during production at the time of placement.

4.4 REVISED MIX DESIGN METHOD (VERSION 2)

After the evaluation of the proposed mix design method, and due to the available time available to complete the project, the following revisions were made to the mix design method:

- To determine the optimum binder content (step 4), it was the original intent to run the LWT at three different temperatures: 95 °F, 77 °F, and 59 °F. This will be modified to run the LWT at 77 °F only.
- To determine deformation properties, the proposed mix design method recommended using TB109. The revised method will measure deformation properties using TB147 instead.

The mix design method reflecting the two revisions discussed above will be as follows:

Step 1: Materials Selection

To begin the mix design, the current ISSA recommendations will be used. Step 1 is subdivided into the following steps, in the order given:

- Selection of aggregate: The first step is to choose the aggregate grading based on the existing ISSA specifications. In addition, the selected aggregate must meet the minimum requirements for mechanical and chemical properties in the specifications prepared as a result of this study.
- Selection of the emulsion and binder: This will be largely a matter of the climatic conditions where it will be applied, and available supply. These parameters are included in the project's specifications.
- Selection of a locally available potable water source.
- Selection of a mineral filler, Portland cement, or hydrated lime, which meets the specification requirements.
- Selection of a liquid retardant such as Aluminum Sulfate when necessary.
- Include a set control additive at the addition rate recommended by the emulsion supplier if necessary.

Step 2: Create a Mix Matrix and Determine Mix Constructability

After the materials have been selected, it will be necessary to determine the proportions of aggregate, water, emulsion, and additives to create a mix matrix. This step will involve the use of the AMT test to determine the mix and spread indices. With the results of the AMT, the conditions at which the materials can be mixed safely and placed in a timely fashion can be

determined. These tests will be performed at standard laboratory conditions and repeated for selected mixes for a range of anticipated application conditions.

This process should be repeated with different filler types (if necessary) to optimize the mixture for constructability and performance criteria. This will lead to a recommended filler type and additives levels to be used.

Step 3: Determine the Short-term Constructability Properties

This step consists of taking the acceptable mixes and conducting cohesion testing using the ACT. The cohesion test is performed at 60 minutes and after 24-hours of cure. This testing would be repeated for specified application conditions of the project. If the results do not meet the standards, then the mixes and materials would be modified as required. In all cases, it is important to ensure that the mix time and spreadability are acceptable. Spreadability is a measure of the ability of the mix to be placed and finished on the pavement surface.

After the proportions have been selected, the ACT test should be performed and repeated for anticipated curing conditions to evaluate the short-term abrasion properties.

The mix proportions can then be modified if necessary and a check performed to confirm that the cohesion at 60 minutes provides an acceptable traffic time and the cohesion at the 24-hour cure period is also acceptable.

The results of step 3 are used to establish a target optimum for the next step in the design, and to evaluate the short-term abrasion properties of the selected mix.

Step 4: Determine the Optimum Binder Content

This involves preparing selected samples for the specific application conditions and varying the emulsion content ±2 from the target optimum. The additive and filler proportions will remain as determined from the targets developed in step 3.

Under this step the WTAT will be performed at 1-hour and 6-day soak periods followed by tests using the LWT to determine the excess asphalt at 77°F.

The recommended optimum binder content will be selected by evaluating the abrasion loss in the WTAT test and the binder content versus sand adhesion from the Loaded Wheel Tester (LWT).

NOTE: The specification minimums established by this study will be used for abrasion loss and the maximum for sand pick up from the LWT.

Step 5: Evaluate the Cohesion Properties at Various Curing Conditions

The selected curing conditions should be representative of the project's estimated humidity and temperature conditions at the time of construction. CAT test is then performed at 30 minutes, 1 hour, and 3 hours.

Step 6: Evaluate the Long Term Properties of the Mixture

This step consists of evaluating the following:

- Abrasion: Using the CAT.
- Water Resistance: Using the Modified WTAT.
- Deformation (rut-filling mixes only): TB 109

Finally, any necessary adjustments and re-check of the mixing indices (spread ability, traffic, and 24 hour cohesion) will be made.

After selecting the best mix from the short-term test methods noted above, the mix will be tested for the following long-term performance properties:

- Abrasion resistance
- Water resistance
- Deformation

Abrasion Resistance:

This property will be measured using the CAT test using fully cured specimens, soaked for 6 days, under project specific environmental conditions.

Water Resistance:

The CAT abrasion test will be run on the final mix design after being soaked for 6 days at a temperature of 77 °F and comparing the loss to that of a 1-hour soak and express this as a ratio. This information will be compared to the results of an existing mixture in order to determine the appropriate specification limits. The test will then be checked with a mix of known standard properties using other materials with which the team and advisory group have experience.

Deformation:

This property will be measured using TB147 "Test Methods for Measurement of Stability and Resistance to Compaction, Vertical and Lateral Displacement of Multilayered Fine Aggregate Cold Mixes".

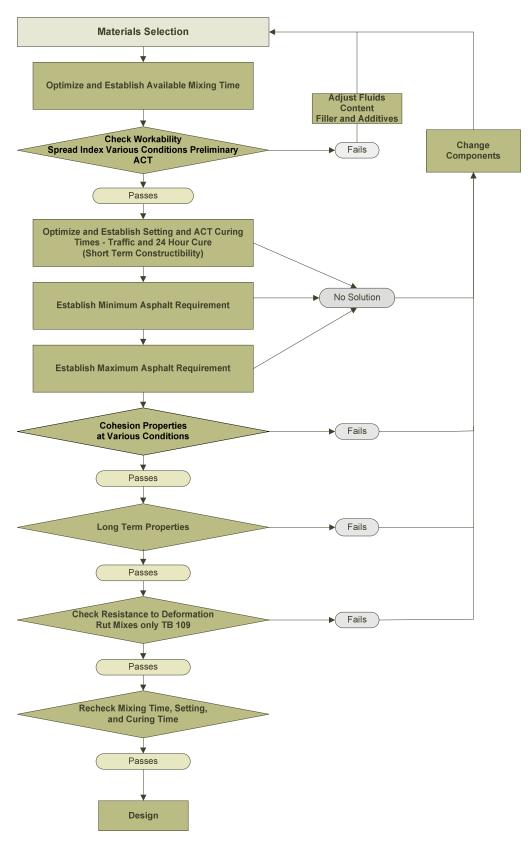


Figure 4.33: Revised Mix Design Method

5.0 CHAPTER 5 RUGGEDNESS TESTING

5.1 PURPOSE OF THE EXPERIMENTS

The overall purpose of a *Ruggedness Testing Experiment* is to evaluate the sensitivity of the output of a particular test to allowable variation in the test conditions. For example, consider a simple hypothetical test method involving a device that can be used to measure the sodium content in a given sample of water. Under the range of typical test conditions, the result of this test may be sensitive to the variability of such factors as the temperature of the water, the amount of solar radiation, and the level of other chemicals and contaminants in the water. A ruggedness test for this device (test method) would involve the design and conduct of an experiment to determine the overall effect of the variation of these other factors on the primary test result (i.e., the sodium content of the water). If the test result is unaffected by the variation of the other factors (within their typical ranges), then the test method is considered *rugged*.

Obviously, ruggedness is a desirable attribute for all test methods, including those that will be used for slurry/micro-surfacing mix design. For any given test method associated with the mix design process, the evaluation of ruggedness can best be done by performing all of the tests in one laboratory, so that there is no laboratory effect to consider. The results from the ruggedness experiment will then provide a basis for evaluating the effect of test conditions under later round-robin testing of the test methods.

5.2 STATISTICAL MODEL

For each of the test devices/methods undergoing the ruggedness testing, the *statistical model* that will be used to evaluate the effect of the variability of test conditions will be a simple linear model. This means that each of the condition variables (X1, X2, X3, and so on) will be evaluated as if they have a linear effect on the dependent variable (i.e., the value of the test result). Considering the overall purpose of the analysis, it is reasonable to assume that the sensitivity can be characterized and evaluated using first order (linear) effects (see Figure 5.1a). Although the relationship may have some curvilinearity, the linear model does capture the primary effect in the region between the low and high levels of the condition variable.

The one case where this assumption can break down is the situation where the condition variable has a quadratic effect and the low and high levels of the condition variable are set at points where they have a near-equal effect on the test result (see Figure 5.1b). In this case, the model would indicate a near zero effect, when the effect is actually significant. Considering the

small likelihood of this happening versus the cost of expanding the experiment design to test for it, the project team recommended erring on the side of minimizing the cost of testing.

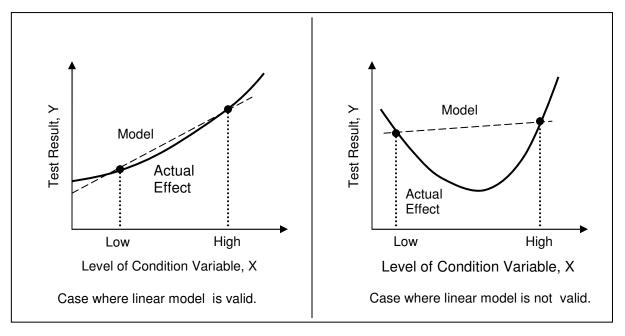


Figure 5.1a: Linear Statistical Model

Figure 5.1b: Non Linear Statistical Model

5.3 PROPOSED EXPERIMENTAL PLAN

Following is a description of the experimental plans and designs for ruggedness testing of the three different test methods associated with the new mix design method. For each test method, a certain number of tests must be performed in order to determine its ruggedness. The individual tests performed for each test method are completed according to a statistically designed experiment involving a) a specified number of tests conducted in a random order prescribed by the experiment design, and b) two (high and low) levels of the condition variables. For each test method, the condition variables are identified as individual independent variables, in accordance with the general form of the *simple linear model*. The levels of each of the condition variables for an individual test observation (Obs.) are coded as follows:

- -1 for low levels
- +1 for high levels

These levels will be far enough apart for the estimated coefficients to be precise, but close enough for the linear model to provide a reasonable fit, two conflicting requirements.

Following are the planned experiment designs for each test method:

- AMT mixing test
- CAT short term test
- ACT test

5.3.1 AMT Test

For this test, the condition variables are:

- X1 Filler Proportion
- X2 Additive Proportion
- X3 Water Content
- X4 Emulsion Content
- X5 Temperature
- X6 Humidity

With six condition variables, a Plackett-Burman design with three replications will be a good choice. If the replications are assumed to be run in 3 *blocks*, there will be 12 degrees of freedom for the estimation of the standard deviation of the measurements and this should provide the precision in the estimates of the parameters in the model as well as for their standard deviations.

A Plackett-Burman design for the six condition variables associated with this test method is given below.

Table 5.1: Plackett-Burman Design for the Six Condition Variables

Observation	X1	X2	Х3	X4	X5	Х6
1	+1	+1	+1	-1	+1	-1
2	-1	+1	+1	+1	-1	+1
3	-1	-1	+1	+1	+1	-1
4	+1	-1	-1	+1	+1	+1
5	-1	+1	-1	-1	+1	+1
6	+1	-1	+1	-1	-1	+1
7	+1	+1	-1	+1	-1	-1
8	-1	-1	-1	-1	-1	-1

Ruggedness tests results for the AMT are contained in Appendix C.

5.3.2 CAT Test

For this test, the condition variables are:

- X1 Cure Time
- X2 Cure Temperature
- X3 Humidity of Cure
- X4 Test Time (Abrasion Time)
- X5 Test Temperature
- X6 Duration of Test

Since compaction was evaluated and considered not necessary, this is not a variable for which its value is to be controlled as is the case for the other condition variables whose effects are being studied. The experiments will be the same and the same as the Plackett-Burman experiment given for the AMT, with three replications of selected combinations. There will not be an X7 variable, but the other six variables will be as given.

5.3.3 ACT Test

For this test, the condition variables are:

- X1 Cure Temperature
- X2 Cure Time
- X3 Cure Humidity

Three replications of a half replication of a 2-cubed factorial will be used for this experiment. One such plan is given below with the coded values for the conditions:

Table 5.2: Three Replications of a Half Replication of a 2-Cubed Factorial

Obs.	X1	X2	Х3
1	-1	-1	+1
2	-1	+1	-1
3	+1	-1	-1
4	+1	+1	+1

5.3.4 Randomization Requirements

It is essential that the experiments be carried out in a randomized order so that there will be a valid estimation of the true experimental error standard deviation as well as the precise estimation of the effects of the condition variables. Randomization made the conduct of the equipment less efficient; however, it was necessary to properly address ruggedness. This was originally intended to be done by the project team using the procedure specified by the project statistician.

5.4 CONCLUSIONS AND RECOMMENDATIONS

Due to the cancellation of the project, the conclusions and recommendations section of the ruggedness testing was not conducted. More research should be considered in order to evaluate the ruggedness of the testing apparatus developed for this project.

6.0 CHAPTER 6 SLURRY SURFACING SYSTEM (3S) STRAWMAN SPECIFICATION

6.1 DESCRIPTION

This work consists of furnishing and placing a slurry surfacing system meeting the requirements of this specification. The mixture shall consist of a combination of an emulsified asphalt, mineral aggregate, mineral filler, water, and other necessary additives, mixed and placed on the pavement surface in accordance with the dimensions shown on the plans.

Any modified ingredient shall be milled or blended into the asphalt or blended into the emulsifier solution prior to the emulsification process. The emulsion supplier shall provide a certificate that the emulsion supplied to the project conforms to the requirements of Table 1.

6.1.1 ASPHALT EMULSION

The asphalt emulsion used shall conform to the requirements of Table 1. Any modified ingredient shall be milled or blended into the asphalt or blended into the emulsifier solution prior to emulsification process. The emulsion supplier shall provide a certificate that the emulsion supplied to the project conforms to the requirements of Table 6.1.

Table 6.1: Asphalt Emulsion Requirements

rable 0.1. Asphalt Emulsion nequirements							
PROPERTY	Test Method	Minimum	Maximum				
Viscosity, Saybolt Furol @ 77°F, Seconds	AASHTO T 59	20	100				
Storage Stability test, one day, %	AASHTO T 59	-	1				
Particle Charge test	AASHTO T 59	Positive					
Sieve Test, %	AASHTO T 59	-	0.1				
Tests on Distillation							
Oil distillate, by volume or emulsion, % residue	AASHTO T 59	60	-				
Tests on Residue							
Penetration, 77°F, 100g, 5 sec	AASHTO T 49	55	90				
Ductility, 77° F 5 cm/min, cm	AASHTO T 51	70	-				
Solubility in trichlorethylene, %	AASHTO T 44	97.5					
Softening Point, minimum	AASHTO T 53	135 ° F					

6.1.2 AGGREGATE

Mineral aggregate shall meet the quality requirements in Table 6.2 and meet the grading requirements in Table 6.3. The grade of aggregate shall be as specified on the project plans.

Table 6.2: Aggregate Quality Requirements

Test	Test Method	Requirement
Sand Equivalent, min	AASHTO T 176	65
Los Angeles Abrasion, loss at 500 rev., max*	AASHTO T 96	35
Percentage of Crushed Particles, minimum	AASHTO T	100
Magnesium sulfate soundness, max. loss, %, 4 cycles	AASHTO T 104	20
Micro-Duval, loss, %**	AASHTO	Report

Note * The abrasion test is to be run on the parent aggregate

Table 6.3: Aggregate Grades

Table 6.3: Aggregate Grades									
Grade	US Sieve Size		Passing by Weight, %	Job Mix Formula Tolerance Limits, %+ -					
Α	3/8	9.5 mm	100	5					
	#4	4.75 mm	70-90	5					
	#8	2.36 mm	45-70	5					
	#16	1.16 mm	28-50	5					
	#30	600µm	19-34	3					
	#50	330 µm	12-25	3					
	#200	75 µm	5-15	2					
В	3/8	9.5 mm	100	5					
	#4	4.75 mm	94-100	5					
	#8	2.36 mm	65-90	5					
	#16	1.18 mm	40-70	5					
	#30	600 µm	25-50	3					
	#50	330 µm	18-30	3					
	#200	75 µ	5-15	2					
С	3/8	9.5 mm	100						
	#4	4.75 mm	100	5					
	#8	2.36 mm	90-100	5					
	#16	1.16 mm	65-90	5					
	#30	600µm	40-65	5					
	#50	330 µm	25-42	4					
	#200	75 μm	10-20	2					

6.2 STOCKPILE AND STORAGE.

If the mineral aggregates are stored or stockpiled, they must be handled in a manner that will prevent segregation and contamination. The aggregate will be accepted at the job site stockpile or when loading into the units for delivery to the laydown machine. The stockpile shall be accepted based on five gradation tests according to AASHTO T2. If the average of five tests is within the gradation tolerances, the materials will be accepted. If the test results indicate that

^{**} The Micro-Duval is to be run on the project stockpile aggregate

the material is outside the gradation limits, the material will be removed from the stockpile site or blended with other aggregate from the stockpile to achieve an acceptable product. Materials used for blending shall meet the requirements of Table 6.3 and shall be blended in an acceptable manner to assure a consistent product. Blending will require a new mix design.

The aggregate shall be passed over a %-in (9.5-mm) scalping screen prior to transfer to the laydown machine to remove oversize material.

6.2.1 WATER AND ADDITIVES.

Water shall be potable and free from harmful soluble salts or other contaminants.

The slurry surfacing mixture shall be homogeneous during and following mixing and spreading and possess sufficient stability to prevent premature breaking in the spreading equipment. Additives may be added to the emulsion mix or any of the component materials to provide control of the setting characteristics of the mixture. They must be included as part of the mix design and be compatible with the other components of the mix.

6.2.2 MINERAL FILLER.

Mineral filler may be used in the mixture and shall be introduced into the mineral aggregate and shall be an approved brand of non-air entrained Portland cement or hydrated lime that is free from lumps. Visual inspection and supplier certification are required. The amount of mineral filler to be added shall be part of the mix design process and shall be considered as part of the aggregate gradation. If additional consistency is required during the placement of the mixture, a +/- one percent change in mineral filler will be permitted without requiring a new mix design.

6.3 PAVING MIXTURE

Prior to the beginning of work, the contractor shall submit a proposed mix design for approval to the contracting agency. A laboratory capable of performing the tests that are noted in Table 6.4 shall perform the mix design. The proposed slurry surfacing mixture shall conform to the requirements of Table 6.4. The percentages of each individual material shall be shown on the design form.

Field adjustments may be necessary once the work is under way but individual materials shall be within the limits contained in Table 6.5.

Table 6.4: Slurry Surfacing Mix Design Requirements

_	Table 6.4: Slurry 3	Juliuolli		Traffic		Temperature			Humidity	
Set	Test or field Condition		Hi	Med	Low	Hi	Med	Low		Normal
Time						35 C	25 C	10 C	90%	50%
	PFS-1 (Mixing)									
	Mixing Torque - maximum	kg-cm	9	9	9	9	9	9	9	9
	Mixing time - minimum	sec.	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120									
	sec.	kg-cm	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	-	clear water	clear water	N/A	clear water	clear water	clear water	clear water	clear water
	Coating	-	100%	100%	95%	95%	95%	100%	100%	95%
Rapid	PFS-2 (Wet Cohesion)									
•	30 min. cohesion - minimum	kg-cm	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	kg-cm	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	kg-cm	25	25	25	25	25	25	25	25
	12 hr. cohesion - minimum	kg-cm	28	28	28	28	28	28	28	28
	PFS-3 (Abrasion Loss)									
	30 min. loss - maximum	g/m²	200	200	400	300	300	300	300	300
	1hr. loss - maximum	g/m²	100	100	300	100	200	100	100	200
	3 hr. loss - maximum	g/m²	100	100	200	100	100	100	100	100
	PFS-1 (Mixing)									
	Mixing Torque - maximum	kg-cm	9	9	9	9	9	9	9	9
	Mixing time - minimum	sec.	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120									
	sec.	kg-cm	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	_	clear	clear	N/A	clear	clear	clear	clear	clear
	Capting		water	water		water	water	water	water	water
	Coating PFS-2 (Wet Cohesion)	-	100%	100%	95%	95%	95%	100%	100%	95%
Slow	30 min. cohesion - minimum	kg-cm	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	kg-cm	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	kg-cm	25	25	25	25	25	25	25	25
	12 hr. cohesion - minimum	kg-cm	28	28	28	28	28	28	28	28
	PFS-3 (Abrasion Loss)	ng om	20			20	20		20	20
	30 min. loss - maximum	g/m²	200	200	400	300	300	300	300	300
	1hr. loss - maximum	g/m²	100	100	300	100	200	100	100	200
	3 hr. loss - maximum	g/m²	100	100	200	100	100	100	100	100
	ווו. וווסט - ווומאוווועווו	y/III	100	100	200	100	100	100	100	100

Table 6.5: Allowable Field Adjustment

Component	Adjustment
Slurry System Residual Binder Content	5.5% - 9.5% by dry mass of aggregate
Water and Additives	As needed
Mineral Filler	0% - 3% by dry mass of aggregate

6.4 APPLICATION RATE

The slurry surfacing shall be of the proper consistency at all times in order to provide the application rate required by the plans and specifications to meet the surface conditions. The average single application rate, if not specified, shall be in accordance with the requirements of Table 6.6.

Table 6.6: Application Rates

Aggregate Grade	Facility	Application Rate		
^	Primary and Interstate Routes	15-30 lbs./yd²	8.1-16.2 kg/m ²	
A	Wheel Ruts	See Section 6. (d). 2		
В	Urban, Residential Streets, Airfield Runways & Taxiways	10-20 lbs./yd ²	5.4-18.6 kg/m ²	
С	Parking Areas, Residential Streets, Airfield Runways & Taxiways	8-12 lbs./ yd ² 3.6-5.4 kg/		

6.5 QUALITY ASSURANCE

Prior to the beginning of the project, the contractor shall provide an orientation session for project personnel, a test strip, and project documentation.

6.5.1 ORIENTATION SESSION FOR PROJECT PERSONNEL.

The contractor shall provide a minimum 45-minute orientation session with the project personnel to discuss the construction process, materials control, materials measurement requirements of the project, and any unique project conditions that need to be addressed. This session may be waived at the direction of the engineer.

6.5.2 TEST STRIP.

With the coordination of the owner, the contractor shall arrange for a test strip to be constructed on or near the project site under as reasonable as possible the anticipated placement conditions of time of day, temperature, and humidity. The test strip shall be 300 to 500 feet (91 m-152 m) in length and shall be constructed with the job mix proportions, materials, and equipment to be used on the project. Adjustments to the mix design shall be permitted provided they do not exceed the values stated in Table 6.4. The test strip shall be evaluated by the owner to determine if the mix design and placement techniques are acceptable once the mixture has set and cured. If modifications to the mix design in excess of the values noted in Table 6.4 are necessary, a new mix design shall be prepared and another test strip constructed. The cost of the materials and placement of the rejected test strip shall be borne by the contractor including any removal costs.

6.5.3 PROJECT DOCUMENTATION.

After the project is underway, the contractor shall, on a daily basis, furnish the owner project documentation that includes the total amount of material delivered to the project and the total amount placed through the mixing machine from the dial gauges. The owner's agent shall verify the dial gauge readings and material weights delivered and this information will be used to independently verify the mix proportions.

6.6 CONSTRUCTION REQUIREMENTS

6.6.1 WEATHER LIMITATIONS.

Slurry systems shall not be applied if either the pavement temperature or the air temperature is below 50° F (10° C) and falling. No material shall be applied when there is the eminent possibility of rain or if the finished product is subject to freezing within 24 hours. The mixture shall not be applied when weather conditions prolong opening to traffic beyond a reasonable time.

6.6.2 MIXING EQUIPMENT.

The materials shall be mixed in a specifically designed piece of equipment, either truck mounted for small applications and residential work, or continuous run machine for larger projects such as highways and airports. The machine must be a continuous-flow mixing unit able to accurately proportion and deliver the aggregate, emulsified asphalt, mineral filler, additives, and

water to a continuous flow mixing chamber. The machine shall have sufficient storage capacity for all the mixture ingredients to maintain an adequate supply to the mixing chamber.

6.6.3 PROPORTIONING DEVICES.

Individual volume or weight controls for proportioning each material shall be provided and properly identified. These devices are used in material calibration and may be used to determine the material output on demand.

6.6.4 SPREADING EQUIPMENT.

The mix shall be agitated and spread uniformly in a specially designed box that is equipped with twin shafted paddles or spiral augers that are permanently fixed to the box. A front seal shall be provided to insure there is no loss of the mixture. The rear seal shall be adjustable and act as the final strike-off of the mixture. The spreader box and rear strike-off shall be designed so that a uniform mixture is delivered to the rear strike-off.

The box shall be able to be shifted laterally to compensate for variability in the geometry of the pavement.

6.6.4.1 Secondary Strike-Off.

Where required on the plans, the spreading equipment shall be equipped with a secondary strike-off to provide a satisfactory surface texture. It shall be capable of having the same leveling adjustments as the spreader box.

6.6.4.2 Rut Box.

When the plans require that wheel ruts, depressions, and utility cuts, and others be filled prior to placing the finished wearing course, material shall be placed with a specially designed rut filling spreader box when rut depths are greater than ½ inch (12.7 mm). For ruts of less than ½ inch (12.7 mm), a full width scratch course using the conventional spreader box is acceptable. Rut boxes are typically designed to be 5 feet (1.8 m) or 6 feet (1.8 m) wide. Where ruts exceed 1½ inches (39 mm), multiple passes with the rut box are necessary. All rut filling should be allowed to cure under traffic for at least 24 hours before the final surface course is placed. Mixtures for filling ruts, depressions, utility cuts, and others shall meet the requirements of Type A as specified in Table C.

6.6.5 MACHINE CALIBRATION.

Each unit to be used for the placement of slurry systems shall be calibrated in the presence of the owner's representative. Previous calibration covering the same materials to be used may be acceptable provided that no more than 60 days has elapsed. The calibration documentation shall include an individual calibration of each material at various settings that can be related to the metering devices on the machine. No equipment shall be permitted to work on the project without a completed calibration.

6.6.6 WORKMANSHIP.

When placing slurry surfacing mixtures, the longitudinal and transverse joints shall be uniform, neat in appearance, and not contain material build-up or uncovered areas. Longitudinal joints shall be placed on lane lines, edge lines, or shoulder lines and shall have a maximum overlap of 3 inches (75 mm). Longitudinal joints shall be straight in appearance along the centerline, lane lines, shoulder lines, and edge lines.

The finished surface shall have a uniform texture free from excessive scratch marks, tears, or other surface defects. A total of four tear marks are considered to be excessive when they exhibit the following criteria:

- ½ inch (13 mm) wide or wider
- 6 inches (150 mm) or more long
- Within 100 yd² (85 m²) of any mark that is:
 - o 1 inch (25 mm) wide or wider
 - o Or 4 inches (100 mm) long.

The contractor is expected to produce neat and uniform longitudinal and transverse joints. Transverse joints shall be constructed as butt-type joints. Joints are acceptable if there is no more than a ½-inch (13-mm) vertical space for longitudinal joints, and no more than 3/8 inches (9 mm) for a transverse joint between the pavement surface and a 4-foot (1.2 m) straightedge placed perpendicular on the joint.

6.6.7 SURFACE PREPARATION.

Immediately before applying the slurry surfacing, the pavement surface shall be cleaned of all loose material, vegetation, and other objectionable materials. Any standard cleaning procedure is acceptable. If water is used, cracks shall be permitted to dry thoroughly before applying the slurry mixture. A suitable method shall be used to cover service entrances (i.e., manhole

covers, valve boxes). No dry aggregate, either spilled from the mixing machine or existing on the pavement surface, will be permitted.

6.6.8 TACK COAT.

If required on the plans, a tack coat consisting of one part SS or CSS emulsion and three parts water shall be applied with a standard distributor. The distributor shall be capable of applying the diluted emulsion at the rate of 0.5 to 0.10 gallons/yd2 (0.16-0.32 liters/m2). The tack shall be allowed to cure sufficiently before the application of the slurry surfacing.

6.6.9 CRACKS.

Existing cracks on the surface of the pavement shall be treated with an acceptable material well in advance of the placement of the slurry surfacing. The surface of the crack filling material shall be 1/8 inch (3.175 mm) below the surface of the roadway.

6.6.9.1 Handwork.

In areas where the placement equipment cannot work because of space limitations, these areas should be surfaced using hand tools to provide a complete and uniform coverage. These areas should be cleaned and lightly dampened before placing the mix. The finished texture shall be uniform and have a neat appearance as nearly as possible to that produced by the spreader box.

6.6.9.2 Application.

The surface of the pavement shall be pre-wetted by fogging ahead of the spreader box. The rate of application shall be adjusted during the placement based on the temperature, texture of the pavement surface, and humidity.

6.6.9.3 Clean Up.

All areas including service entrances, gutters, and intersections shall be cleaned of the slurry surfacing on a daily basis as well as any debris associated with the placement.

6.7 METHOD OF MEASUREMENT

6.7.1 AREA

On small projects, less than 50,000 yd2 (41,805 m2), the method of measurement and payment shall be based on the area covered, which is measured in square feet, square yards, or square meters.

On projects larger than 50,000 yd2 (41,805 m2), the measurement is based on the quantity of aggregate (tons or metric tons) and emulsified asphalt (gallons or liters) that are used. The aggregate is measured by the actual weight delivered to the project laydown site or is weighed at the stockpile with certified scales. Delivery tickets or printed weights shall be used for measurement. The emulsified asphalt will be measured by certified tickets for each load delivered to the project. Unused or returned emulsion will be deducted.

6.8 BASIS OF PAYMENT

The slurry surfacing shall be paid for by the unit area or the quantities of the aggregate and emulsified asphalt used and accepted on the project. The price shall include furnishing, mixing, and applying the slurry surfacing; labor, equipment, tools, mix design, test strips, surface preparation, and incidentals necessary to complete the project.

7.0 CHAPTER 7 SUMMARY AND CONCLUSIONS

7.1 SUMMARY

[This study, "Slurry Seal/Micro-Surfacing Mix Design Procedure", was conducted from July 2003 to November 2008 by Fugro Consultants Inc., Austin, Texas serving as the prime contractor with support from Applied Pavement Technology, Inc., Urbana, IL, MACTEC Engineering and Consulting Co., North Highlands, CA and CEL Laboratories, Oakland CA. The project was the result of a 14 state pooled fund solicitation managed by the California Department of Transportation.

The purpose of the study was to develop a rational mix design procedure for slurry seal and microsurfacing mixtures. After conducting an extensive national and international literature review and an industry survey of existing practices, the research team posited a mix design process that formed the basis for the remainder of the study. A number of possible test methods were identified that would potentially assist the study in identifying the characteristics of slurry surfacing mixes that relate to mixing, spreading, and curing. The intention was to use procedures, either existing or developed ones that would minimize operator (technician) bias and also relate to various placement conditions in the field.

Two test procedures that had been used in Europe, the "German" mixing test (which the team renamed the AMT) and the "French" Wet Track Abrasion Test (renamed the CAT) were identified in the literature survey and were selected to be studied in comparison to existing International Slurry Surfacing Association test methods TB 113 and TB 100. A third procedure, an automated cohesion tester, was developed by an equipment manufacture for the study and was named the ACT.

The benefit of using the automated mixing test, once all the equipment details were worked out, was the standardization of the mixing process under various temperature and humidity conditions that could be expected in the field. The CAT was adopted since the method used standard equipment used in TB 100 but used the entire gradation of the mix unlike TB 100 in which the plus #4 material is scalped off. The ACT eliminates the operator bias associated with the torque wrench that is used to apply the load to the specimen.

In addition to the test procedure development, test protocols were developed for both the AMT and CAT and ruggedness testing was conducted for both test methods.

Delays in the progress of the research because of personnel transfers and equipment issues caused the research team to request two no-cost time extensions to the contract. The first was granted which extended the project for one year through October 2008 and the second one was not. The result was that there was approximately \$75,000 in contract funds unspent and we were not able to complete the ruggedness testing and test protocols for the ACT nor were we able to construct test sections to validate the new test methods. The details for the construction of the test sections are included as an appendix to the final report should some agency wish to pursue this activity.

7.2 CONCLUSIONS

It is reasonable to conclude that the study, in spite of the delays and setbacks, was successful in attempting to identify test procedures that relate mixtures produced in the laboratory to field performance. As stated in the report and summarized above, we unfortunately were not able to validate the laboratory procedures to performance. Significant progress was accomplished during this study to develop test procedures that reduce operator bias but more work needs to be done to possibly improve the ACT test equipment, develop a test protocol, and conduct ruggedness experiments.

Agencies or industry partners should be encouraged to further the work by conducting field projects to validate this study and to modify where necessary the test methods proposed.

As often happens with any experimental research study, unanticipated circumstances arose to preclude this study from reaching a concise and implementable conclusion but the work conducted and reported on improves the state of the knowledge of slurry surfacing systems.

APPENDIX A PROPOSED TEST METHOD FOR THE AUTOMATED MIXING TEST (AMT)

Constructability of Asphalt Emulsions and Aggregate Mixture Systems [Automated Mixing Test (AMT)]

AASHTO Designation xxxx: Draft Proposed Test Method

1.0 SCOPE

- 1.1 The test method covers measurement of the constructability of slurry surfacing materials once basic ratios of components have been established. By automatic and constant recording of the complete torque- measurement-curve, the mixing curve indicates each variation during the breaking process. The evaluation takes place under controlled conditions and the control system provides an automatic report of results.
- 1.2 The main parameters that are measured are:
 - Mixing Torque (Mix Index)
 - Mixing Time
 - Spread Time
 - Maximum Torque (Spread Index)
- 1.3 The test method is in development.
- 1.4 The values stated in SI units are to be regarded as the standard.

2.0 REFERENCED DOCUMENTS

- 2.1 International Slurry Surfacing Association (ISSA) Technical Bulletin (TB) 113, Trial Mix Procedure for Slurry Seal Design.
- 2.2 Thin Lift in Cold-Applied Micro-Surfacing, Instructions for the Electric Mixing Test, (Translated from German).

- 2.3 Computer software: Labsoftworld 4.5.
- 2.4 IDA Werke EUROSTAR Power control-visc manual.
- 2.5 Velp Scientific mixing stirrer manual.

3.0 TERMINOLOGY

- 3.1 Definitions:
- 3.1.1 Mixing Torque (Mix Index), N-cm: the torque value measured in the initial, relatively flat portion of the torque-time plot, where mixing takes place without a significant increase in the measured torque.
- 3.1.2 Mixing Time, minutes: the amount of time over which mixing takes place without significant increase in the measured torque; or the amount of time corresponding to the initial, relatively flat portion of the torque-time plot before the torque-time plot begins to increase.
- 3.1.3 Spread Time, minutes: the amount of time over which the torque increases from the Mixing Torque value to a value of 12 N-cm.
- 3.1.4 Maximum Torque (Spread Index), N-cm: the maximum torque measured before the mix breaks and becomes brittle.
- 3.1.5 Breaking Time, minutes: the total amount of time until the mixture breaks by observation.
- 3.1.6 Pre-Wet Water: The amount of water added to the dry aggregate and dry additive, when applicable. This moistens the aggregate before adding the liquid additive and asphalt emulsion.

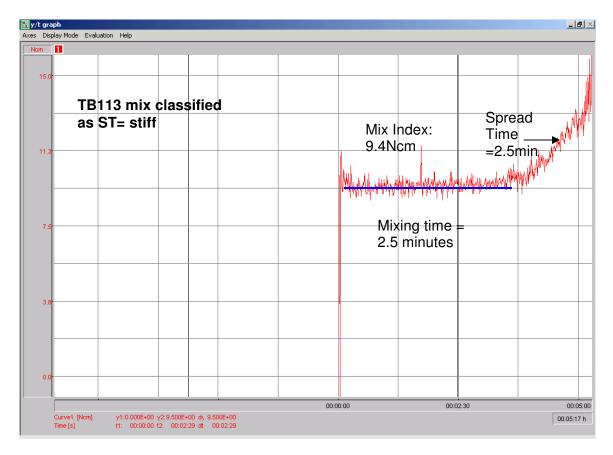


Figure A.1: Representation of Definitions

4.0 SUMMARY OF METHOD

- 4.1 The asphalt emulsion, aggregate, set control additives, and water are the components of the mix. The mix components, at the prescribed temperature, are weighed into a test container. Other components to be added are determined by the mix design or through pre-testing using the hand mixing method, ISSA TB 113. The asphalt emulsion and water (with additive) are placed in the container after being conditioned at the test temperature. The mixing cup is centered under the stirrer and lowered to 1.5 mm from the bottom of the cup. Then rotation of the stirrer is started manually and maintained at 50 rpm for 5 sec. The test measurements are captured by the control system. The mix is stirred until it either breaks or 10 minutes have elapsed.
- 4.2 The breaking of the mixture is also visually observed. The surface of the mixture in the bowl will appear very rough and coarse. At this point the mixture fragments into parts and free liquid may be observed.

4.3 If the mix does not break, the test is terminated at 10 minutes mixing and observations made as to greater than or less than the specification level.

5.0 SIGNIFICANCE AND USE

- 5.1 This test method will measure compatibility and setting parameters of asphalt emulsions and mineral aggregates.
- 5.2 This procedure is suggested for establishing design criteria of the mix system. In addition, it provides a means of quality control during the production of asphalt emulsion, mineral aggregates, and additives.
- 5.3 This method facilitates research and development of new combinations of raw materials.
- 5.4 This method documents the temperature influences on the consistency of the mixed materials.
- 5.5 This method measures the affect of compositional changes on mixing.

6.0 APPARATUS

- 6.1 The AMT System set-up is illustrated in Figure A.2.
- 6.2 IKA Werke EUROSTAR power control-visc, R1826 Plate Stand, R182 Boss Head, RH3 Strap Clamp
- 6.3 Velp Scientific stirring shaft with propeller: 3 stainless steel blades, 60 mm, shaft 400 x 7 mm
- 6.4 Mixing bowl: stainless steel, 10 oz, 7cm tall, 5 cm radius with a rounded flat bottom (Vollrath #99637)
- 6.5 Balance accurate to 0.1 g

- 6.6 PC capable of running labworldsoft 4.5 software by IKA Werke (Windows 2000 or higher), with Excel® software program.
- 6.7 Thermometer calibrated between 0 ℃-50 ℃
- 6.8 Spatulas
- 6.9 Constant temperature cabinet or room



Figure A.2: Testing Apparatus

7.0 SAMPLE PREPARATION

- 7.1 Aggregates: Sample representative portions of aggregates used for slurry seal mix or micro-surfacing mix. Use material of the type, grade, and source proposed for the project. Aggregates shall be dried at $60\,^{\circ}$ C to a constant mass and cooled to the prescribed test temperatures prior to performing the test.
- 7.2 Bitumen emulsions maintained at the test temperature and representative of the material to be used in the project.
- 7.3 Set control additives both solid and liquid that shall be used in the project.
- 7.4 Distilled drinking water with a pH between 6.0 and 7.0 shall be used.

8.0 PROCEDURE

- 8.1 Maintain the aggregate, emulsion, water, and additives at the test temperature 25°C.
- 8.2 Set up the IKA Werke EUROSTAR ready for test with the control system ready on the correct measurement configuration. See the Appendix for establishing the signal flow.
- 8.3 The amounts of materials shall be quantified by a mix design, from TB113 or in a matrix to determine specific mix effects.
- 8.4 Add 300g of aggregate into the mixing bowl.
- 8.5 Add the required amount of solid additives, when applicable, and mix well by hand.
- 8.6 Add pre-wet water, followed by the liquid additive, when applicable, and mix well by hand. Pre-wet water refers to the amount of water added to dry aggregate to ensure that it is moist prior to mix it with emulsion or liquid additive.
- 8.7 Add the emulsion and quickly blend with the aggregate within 5-10 seconds.
- 8.8 Within 5 seconds, quickly place the bowl and mix contents in the EUROSTAR, such that the bottom of the propeller is 1-2 mm above the inside bottom of the bowl.
- 8.9 Start the mixer manually and mix for 5 seconds
- 8.10 Start test and monitor torque.
- 8.11 Switch off test at 10 minutes or when torque rises to a maximum and then falls off, which ever comes first.

9.0 REPORT

Report the following:

- 9.1 Mixing Torque, N-cm
- 9.2 Mixing Time, minutes
- 9.3 Spread Time, minutes
- 9.4 Maximum Torque, N-cm
- 9.5 Breaking Time, minutes
- 9.6 If the mixture mixes beyond 10 minutes without increasing in torque or breaking, note results as greater than 10.
- 9.7 Blot Test results.

10.0 PRECISION AND BIAS

Additional studies are required. The equipment is still open for further development.

11.0 BLOT TEST

11.1 General Information

The Blot Test is the second step for evaluating the mix proportions determined and tested using the hand mixing method, ISSA TB 113. The Blot Test results indicate several conditions of the mix that represent break.

- 11.2 Terminology
- 11.2.1 Definitions:

- 11.2.1.1 BT: brown color transfer to white absorbent paper towel
- 11.2.1.2 A: aggregate and clear water transfer to white absorbent paper towel
- 11.2.1.3 CW: clear water transfer to white absorbent paper towel

12.0 PROCEDURE

- 12.1 Perform the test at temperatures used in TB 113.
- 12.2 Weigh 100 g of aggregate into a suitable mixing bowl.
- Add the desired amount of dry mineral filler or additive and hand mix dry with spatula at 60 rpm in a circular motion for 10 seconds or until distribution of the dry ingredients are uniform.
- 12.4 Add the desired amount of pre-mix water and hand mix at 60 rpm in a circular motion for 10 seconds or until distribution of the water is complete and uniform.
- 12.5 Add the desired amount of liquid set additive and hand mix at 60 rpm in a circular motion for 10 seconds or until distribution of the liquid additive is complete and uniform.
- 12.6 Add the desired amount of emulsion and hand mix at 60 rpm in a circular motion for 120 seconds.
- 12.7 Remove approximately one-quarter of the mixture onto roofing felt. Spread the mix evenly to a depth of 10-15 cm. Begin timing.
- 12.8 At the end of 30 seconds, blot the mix surface with a white absorbent paper towel. Note the color transfer onto the paper towel.

- 12.9 Repeat the procedure for various mix proportions used for evaluating the mix system being tested.
- 12.2 Report
- 12.2.1 Mix proportions tested.
- 12.2.2 Record the Blot Test results as BT: brown color transfer, A: aggregate and clear water transfer, or CW: clear water transfer.

13.0 Labworldsoft® Signal Flow Diagram Construction for the Automated Mixing Test

13.1 General Information

The Labworldsoft® Computer software is laboratory automation software used in conjunction with the Microvisc (or equivalent) stirrer to measure torque, speed, and time and calculate viscosity per the proposed draft test method, "Constructability of Asphalt Emulsions and Aggregate Mixture Systems."

The laboratory software application controls all of the laboratory equipment with an RS-232 serial interface or analog interface to perform measuring, controlling, and regulating operations. It is operated with the mouse and/or keyboard in the same manner as all Windows® applications.

13.2 Installation

To install, follow the procedures provided with the installation CD. If it is to be started whenever Windows® is launched, copy or drag the "Labworldsoft®" application icon into the "auto start" window.

- 13.3 Starting the Program
 - 1. Switch on Computer
 - 2. Start Windows ®(if not automatic)
 - 3. Connect laboratory instrument to PC
 - 4. Double-Click on application symbol (Labworldsoft® 4.5)

Note: Closing all other programs running in the background will allow the Labworldsoft® program to run at optimum speeds during operation.

13.4 Generating a Signal Flow Diagram for IKA®-Werke Eurostar Power Control-Visc

After starting the program, a blank screen will appear with a menu bar at the top. For purposes of this procedure, the term signal flow diagram is also known as measurement sequence and configuration file.

The first step is choosing functional units for use. Functional units are represented with icons and color coded according to their purpose, listed below.

Blue – Lab instruments (Hardware)

Yellow - Averaging and/or arithmetic operations

Red – Manual or auto control of instruments or files

Green - Displaying results - graphical, numerical, and saving

- 1. Click on "Laboratory Instruments" in the menu bar. A drop down menu will appear. On the drop down menu, go to "IKA Werke." Another drop down menu will appear. On it, go down to "Eurostar Power control-visc" and left click on it. An icon representing this instrument will appear on the page.
- 2. Click on "Module" in the menu bar. A drop down menu will appear. On this drop down menu, go to "Signal Processing." Again, another menu appears. Choose "Mean Value" by left clicking on it. An icon representing mean value will appear on the page.

This process will continue until all functional units are chosen. The following chart is an abbreviation of the steps above.

Menu Bar (click on item)	1 st Drop Down Menu	2 nd drop down menu
Lab Instruments	IKA Werke	IKA Eurostar Power Control Visc
Module	Signal Processing	Mean Value
Module	Controlling	Rated Value
Module	Visualization	y/t graph
Module	Visualization	Digital Instruments
Module	Files	Write

Now that all the functional unit icons are selected, position them on the "page" using the diagram in Figure A.3 by clicking on the icon and dragging it to its location.

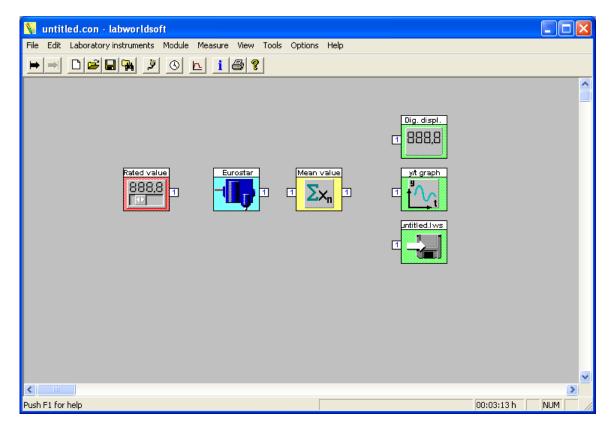


Figure A.3:

If a need arises to remove a functional unit, use the right mouse button; double-click on the icon to be removed.

In the second step, parameters of the functional groups are set in their respective parameter window. This includes the port number for the RS-232 interface and input/output paths for controlling variables or results. After choosing parameters, they appear as numbers on the related symbol.

To change and/or set parameters of each functional unit, double-click on its respective icon. This will bring up the parameter window, when open; you make change/set parameters according to the following. Left click on "OK" when changes have been completed for each functional unit.

 Rated value – change description to "RPM"; go to the RPM window and Restore Up; set rate to "50" and minimize RPM window, if desired

- <u>Eurostar mixer</u> the parameter window will open
 - Click on the drop down menu in the "Port" section. Make sure correct port is chosen, COM1.
 - o In the "Control" box, check on "rated speed".
 - o In the "Measured values" box, check on "Torque trend".
- Mean Value select "Sliding arithmetic mean", Enter "1" for No. of values to be averaged
- <u>Digital Display</u> change the Description to "Torque"; go to drop down menu for unit and select "Ncm".
- y/t Graph this plots torque (y) over time. Go to the drop down menu in the Settings area and select "Ncm" under units. Change the Y-max scale to 20.0. Go to the y/t graph window and Restore Up. Select drop down menu "Display mode", select "Color and Lines", click on "Drawing surface", click on "Color" box and select the white colored tile, and click on "OK". Additionally, click on "Axes", select "Time Scale" and set at 10 minutes.
- Save Data the parameter window will open. Can choose multiple channels for saving multiple pieces of data. For now, make sure one channel is specified. Check the box to "also save data in ASCII file." To save data in a specific location, use the "Path" box. Clicking on that opens the "Save" window and a location/path can be chosen.

See Figure A.4, which should show a final representation of the changes made above.

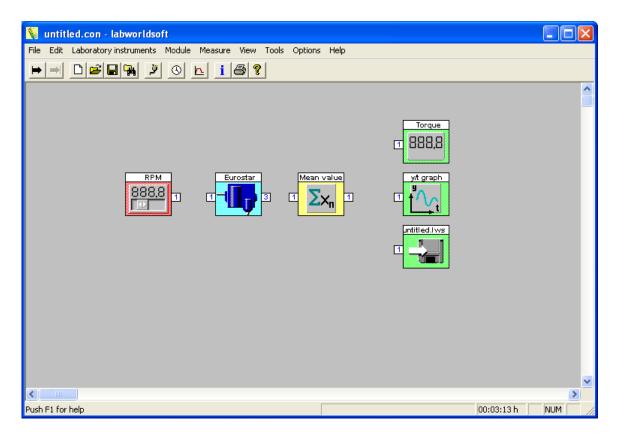


Figure A.4:

In the third step, the signal flow begins to take shape by connecting the input/output paths using anchor points described earlier.

- 1. Left click on the output/number field of the left-handed functional unit. The mouse pointer will change to a hand with a writing instrument.
- 2. Press the left mouse button down and drag the arrow to the input path/number field to be connected.
- 3. Release the mouse button and the connection is created.

Connect each functional unit as in Figure A.5.

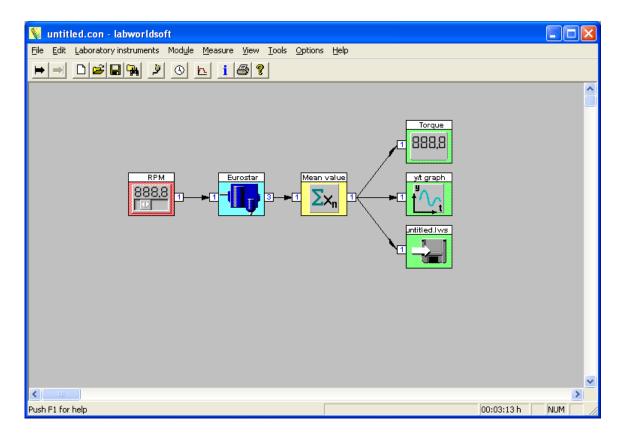


Figure A.5:

If a need arises to remove the connections created, with the right mouse button, double click on the number field of the connection input path to be deleted.

13.5 Displaying Control and Result Windows

Actual control of the sequence takes place in special windows. Depending on the functional control unit (push button, ramping), its control feature will be present. After beginning the measurement sequence, results are displayed in special windows. Depending on the functional result unit, numerical, graphical, and and/or results recording are visible when the window is visible. These windows are not visible initially. A minimized icon version is at the lower edge of screen.

To Restore/maximize control/result windows:

Click on the full screen icon in the right had corner of the minimized icon.

To reduce/minimize control/result windows:

Click on the minimize icon in the upper right hand corner of the enlarged window.

13.6 Test Sample

Refer to the proposed AASHTO test method for instructions regarding equipment and test specimen preparations prior to testing.

13.7 Controlling Measurement Sequence

Before starting the test, have the windows restored as in Figure A.6.

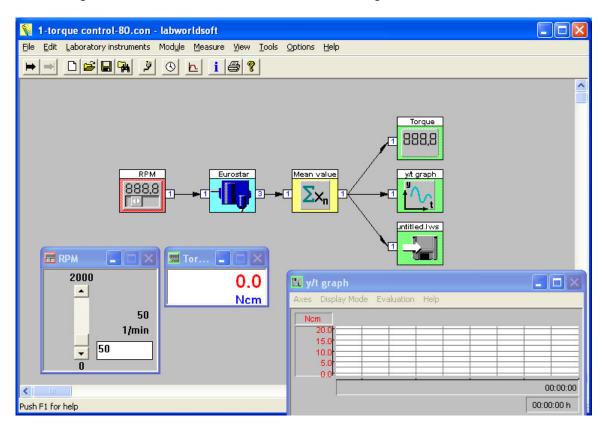


Figure A.6:

For the proposed test method, starting and stopping of the measurement sequence will be controlled manually:

- Select the drop down menu "Measure"
- Place premixed mixture and bowl in testing apparatus
- Set stirrer into the mixture at required distance from the bottom of the bowl
- Turn on power control-visc
- Click on "Start"; a window will pop up prompting to overwrite the file, click on "Yes" immediately to begin recording the torque.

To stop the test, select the drop down menu "Measure" and click on "Stop". A window will pop up prompting to end current measurement. Click "Yes".

13.8 Saving Measurement Sequence

To save the signal flow diagram created, standard windows functions are used. Hold down "CTRL" + "Alt", press "Print Screen" and paste the y/t graph into a Microsoft Work document. Add the mix details: mix description, test temperature, aggregate (g), mineral filler (%), water (%), set additives (%), emulsion (%), mix index, mixing time, spread time, maximum torque, and total time for break.

Save file with an appropriate file name.

To differentiate from other files managed by this software, signal flow configuration files have the extension*.con.

13.9 Other Options

Other options, such as printing, opening, creating new file, etc., are available in the menu bar and icon bar, using standard window functions.

APPENDIX B PROPOSED TEST METHOD FOR THE COHESION-ABRASION TEST (CAT)

DRAFT Proposed Method of Test for Measurement of Cohesion Build Up and Wearing Qualities of Asphalt Emulsions and Aggregate Mixture Systems [Cohesion Abrasion Test (CAT)]

AASHTO Designation xxx: DRAFT Proposed Test Method

1.0 SCOPE

- 1.1 The test method covers measurement of the wearing qualities of slurry seal and micro-surfacing mixture systems under wet abrasion conditions at different levels of cure. The method is also suitable for measuring early cohesion of slurry and microsurfacing mixes under different cure conditions.
- 1.2 The test method is applicable to mixes after the formulation of the slurry seal or micro-surfacing and, its set additives and water contents have been adjusted to prepare homogenous flowing consistency.
- 1.3 The method may be used to assess the stripping potential of aggregates in early life.
- 1.4 The test method is in development.
- 1.5 The values stated in SI units are to be regarded as the standard.

2.0 REFERENCED DOCUMENTS

- 2.1 ASTM D 3910-80a, Practice for Design, Testing, and Construction of Slurry Seal.
- 2.2 ASTM D 6372, Practice for Design, Testing and Construction of Micro-Surfacing.

- 2.3 ISSA TB 100, Test Method for Wet Track Abrasion of Slurry Surfaces.
- 2.4 SCREG Surface Cohesion Test for Slurry Systems, C. Deneuvillers, ISSA 37th Annual Meeting, Mexico, 1999.
- 2.5 ISSA TB 113
- 2.6 AMT Mixing Test

3.0 SUMMARY OF METHOD

- 3.1 Asphalt emulsion, aggregate, setting additives, and water are the components of the mix.
- The proportions of the components will be derived after optimizing the binder content from previous testing as recommended in the mix design. The mix is cured for specific times under prescribed temperature and humidity conditions. After curing, the specimen is weighed and then placed in a circular pan on the planetary type mechanical mixer. Water is placed over the sample; in some cases the sample may be soaked in water before hand. The specimen surface comes in contact with the abrading dual wheel head. The wheels move across the surface in a planetary movement and abrasion occurs for 60 seconds. After the end of abrasion, the specimen debris is rinsed off. The remaining test specimen is dried with an absorbent paper and the final weight is recorded. The difference of the original and final weights is the measured loss of the test specimen.
- 3.3 A loss mass below 100 g is representative of a high cohesion slurry seal or microsurfacing mix. A loss of mass of 100-300 g represents an average cohesion. When the loss of mass is close to 400 g, it is expected that the slurry seal or micro-surfacing mix will not resist traffic early in the curing stages of the system.

4.0 SIGNIFICANCE AND USE

4.1 The test method will measure early stage abrasion resistance and abrasion resistance of cured mixtures.

4.2 The test method can quantify the influence of some formulation parameters on setting time and cohesion build up (such as variations of the mix components or the environmental temperature and/or humidity conditions while laying).

5.0 APPARATUS

- 5.1 The CAT system set-up is illustrated in Figure B.1
- 5.2 Planetary type mechanical mixer, such as Hobart N-50 equipped with a dual wheel abrasion head, quick-clamp mounting plate, and flat bottom metal pan. See Figure 5.1.
- 5.2.1 Ridged Wheels: 100 mm diameter with 22 mm contact width.
- 5. 2.2 Wheel hardness of 75 and 95 (durometer reading) foot.
- 5. 2.3 Abrasion head should weigh between 1100 g and 1150 g.
- 5. 2.4 Aluminum abrasion pan, approximately 55 mm high with an inside diameter approximately 285 mm.



Figure B.1: Testing Apparatus

- 5.3 Stainless steel or aluminum casting plates: 2 mm thick, 275 mm diameter.
- 5.4 Suitable specimen casting mold with 14 mm depth and 250-252 mm inside diameter. A raised lip mold is preferred but a flat surface polymethyl methacrylate or equivalent mold is satisfactory.

- 5.5 Mold strike-off apparatus, such as a wooden dowel, with minimum dimensions: 20 mm diameter by 450 mm long.
- 5.6 Scales, with capacity of 2000.0 g, accurate to +/- 0.1 g.
- 5.7 Wooden prop block or device to support the pan and mounting plate assembly during the test.
- 5.8 Suitable rust-resistant mixing containers and spoons. Additionally, plate removal device with tapered flat tip (for example, a paint can lid opening tool), as pictured in Figure B.2, is needed for carefully placing and removing specimen plates into and from the abrasion pan.

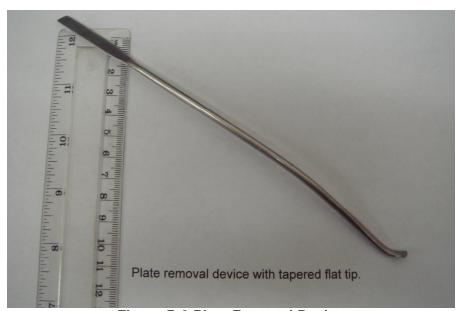


Figure B.2 Plate Removal Device

- 5.9 Constant temperature water bath controlled at specified temperatures.
- 5.10 Absorbent paper towels, single fold, CS Scott or equivalent.
- 5.11 Environmental chambers which can maintain specified curing temperatures and humidity conditions.
- 5.12 Forced air draft ovens for curing long term evaluation specimens at 60°C +/- 3°C.

6.0 MATERIALS

- Aggregates: Sample representative portions of aggregates used for slurry seal mix or micro-surfacing mix. Use material of the type, grade, and source proposed for the project. Use the aggregates that pass the 9.5 mm sieve. Aggregates shall be dried at 60 °C to a constant mass and cooled to the prescribed test temperatures prior to performing the test.
- 6.2 Asphalt emulsion shall be representative of the material to be used in the project.
- 6.3 Set control additives, both solid and liquid, shall be representative of the materials to be used in the project.
- Distilled potable water with a pH between 6.0 and 7.0 shall be used.

7.0 EVALUATION PARAMETERS

- 7.1 Curing duration of specimens: 30 minutes, 1 hour, and 3 hours.
- 7.2 Curing temperatures of specimens: 15°C, 25°C, and 35°C.
- 7.3 Curing humidity of specimens: 50% and 90%.

8.0 PREPARATION OF TEST SPECIMEN

- 8.1 Aggregate, asphalt emulsion, set control additives and mixing water shall be maintained at 25 °C.
- 8.2 The amounts of material components will be quantified as described by the mix design or through determinations from pre-testing using the Automated Mixing Test method.
- 8.3 Split or quarter a sufficient amount of the dried aggregate to obtain in one quarter 1300g to 1400 g, depending on the aggregate specific gravity and maximum nominal size.

8.4 Brush about 5 g of tack coat emulsion (use the same emulsion as is used in the mixture) onto the casting plate so it is evenly covered. See Figure B.3. Allow to dry completely.



Figure B.3: Applying Tack Coat

8.5 Center the specimen casting mold over the casting plate with tack coat as in Figure B.4.



Figure B.4: Centered Casting Mold

8.6 Weigh 1300 g of aggregate into the mixing bowl. Typically, 1300 g of aggregate should be enough aggregate to slightly over-fill the specimen mold during casting. Using a spoon mix in prescribed amount of dry set additive to the aggregate and mix for 1 minute or until uniformly distributed. Add the pre-wet amount of water and mix again for 1 minute or until uniformly distributed. Add the liquid set additive(s) to the mix and mix for 1 minute or until uniformly distributed. Finally, add the predetermined asphalt emulsion and mix for 1 minute or until uniformly distributed. Immediately pour into the centered specimen casting mold.

8.7 Strike off the slurry mixture level with the top of the mold with a minimum of manipulation. Use a sawing motion with the wooden dowel and even out the surface as seen in Figure 8.3. Discard excess material. Remove the mold and cure under prescribed conditions of duration, temperature, and humidity.

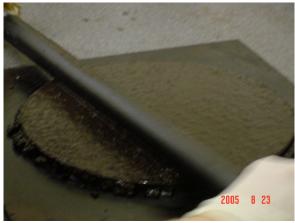


Figure B.5: Surface Preparation

8.8 After the prescribed curing conditions, record the weight of the specimen immediately before placing into the abrasion pan. If there is excess water along the edges of the specimen and surface of the casting plate, carefully remove by dabbing with an absorbent paper towel before recording the initial weight.

9.0 TEST PROCEDURE

- 9.1 Place the cured specimen into the abrasion pan. Clamp the specimen plate to the inside of the abrasion pan; tighten the quick clamps to press against the specimen plate that is in the abrasion pan on the mounting plate.
- 9.2 Completely cover the specimen with water at the specified temperature so that there is approximately 3-4 mm of water over the surface of the test specimen. Soak for 1 minute.
- 9.3 Lift the mounting plate until the surface of the specimen comes in contact with the abrading wheels.
- 9.4 Switch to the low speed of the Hobart machine. Abrade for 60 seconds.

9.5 Lower the mounting plate and remove the specimen plate with the aid of a plate removal device. Carefully rinse the loose debris with 1000 ml to 1500 ml of water. Carefully dry the specimen and casting plate with an absorbent paper towel. Record the final weight.

10.0 REPORT

Report the following information:

- 10.1 Aggregate: percent used, type of aggregate, source and the date received for testing.
- 10.2 Asphalt emulsion: percent used, type of emulsion, source, and the date received for testing.
- Set additive(s): percent used, type, source, and the date received for testing.
- Percent of pre-wet water used to initially wet the aggregate, if needed.
- 10.5 Curing conditions: duration, temperature, humidity, and soaking time.
- 10.6 Testing conditions: machine used, running time.
- 10.7 Abrasion Loss as the result of the initial weight before abrasion minus the final weight after abrasion. The loss is reported in grams.
- 10.8 Observation of failure and stripping of aggregate in test, when applicable.

11.0 PRECISION AND BIAS

Additional studies are required. The equipment is still open for further development.

APPENDIX C RESULTS OF RUGGEDNESS AMT TESTING

Mix 5 was used for performing the AMT ruggedness tests. The target optimized proportions for M5 were 10% emulsion, 8% water, 0% liquid additive, and 0.5% type 2 cement. There were six conditions which were adjusted for evaluation. The room temperature used was either 23 °C or 27 °C. The humidity condition used was either 40% or 60%. The emulsion content used was either 8% or 12%. The liquid additive used was either 0% or 0.1%. The mineral filler proportion used was either 0% or 1%.

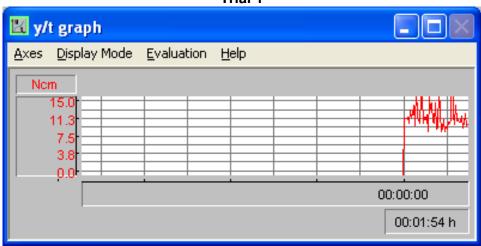
The AMT data for the trials are contained in Table C.1 and the traces fro the trials are illustrated in Figures C.1 through C.4..

Table C.1: AMT Ruggedness Trial Data

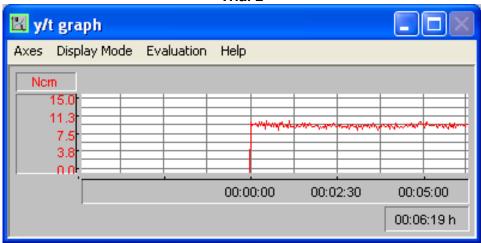
AMT	rugged	ness														
Mix:	M5															
Parameter	Trial #	Cement, %	Chiquid Add, %:Al Sulfate	od Water, %	Emulsion, %	ל temperature, °C	8 humidity, %	မ S Aggregate, g	Cement, %	S Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state o torque	Alix Time: time where steady ப் increas of torque begins	Spread Time: time where Sproque reaches 12 N-cm	:: O Time when mix has broken
1	10	1			8				3		0.3	24				
2	3	0	0.1	10	12	23	60	300	0	30	0.3	36	9.0	2:30	n/a	5+
3	6	0	0	10	12	27	40	300	0	30	0	36	9.5	1:15	n/a	5+
4	12	1	0	6	12	27	60	300	3	18	0	36	9.5	1:15	2:00	3:00
5	5	0	0.1	6	8	27	60	300	0	18	0.3	24	9.0	0:15	0:30	1:00
6	7	1	0	10	8	23	60	300	3	30	0	24	9.5	2:30	3:45	4:30
7	9	1	0.1	6	12	23	40	300	3	18	0.3	36	11.3	1:15	2:30	3:00
8	1	0	0	6	8	23	40	300	0	18	0	24	11.0	0:15	0:40	1:15
	unit	%	%	%	%	С	%									
	design	0.5	0	8	10	25	50									
		4 =:11	0 4 1 1	0 147 1	4 5		0 11									
Parar					4. Emu			naity								
est N	1	0.5	0.1	2	-2	27	40									
	2	-0.5	0.1	2	2	23	60									
	3	-0.5	-0.1	2 -2	2	27	40									
	4	0.5 -0.5	-0.1	-2 -2	-2	27 27	60									
	5 6	-0.5 0.5	0.1 -0.1	-2 2	-2 -2	23	60 60									
	7	0.5	0.1	-2		23	40									
	8	-0.5	-0.1	-2 -2	2 -2	23	40									
	Unit	%	%	%	%	23 C	%									
	UIIIL	70	70	7/0	70	U	7/0									

Figure C.1: Ruggedness Trials

Trial 1



Trial 2



Trial 3

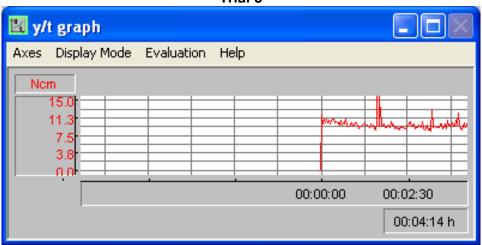
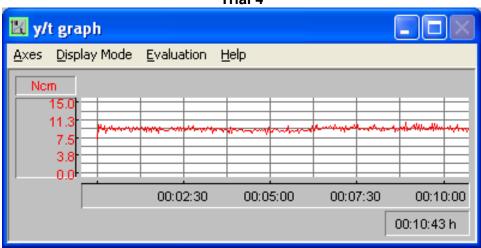
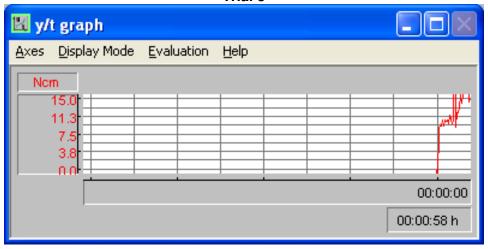


Figure C.2: Ruggedness Trials

Trial 4



Trial 5



Trial 6

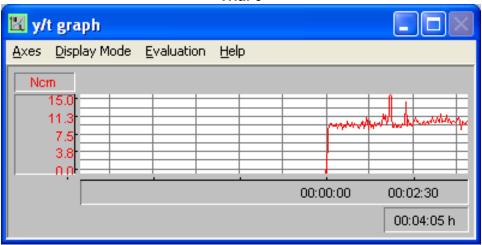
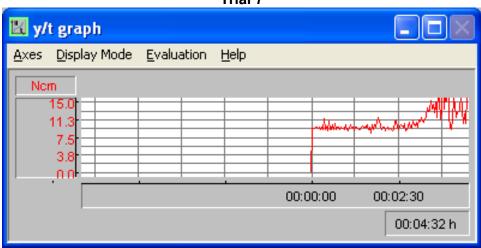
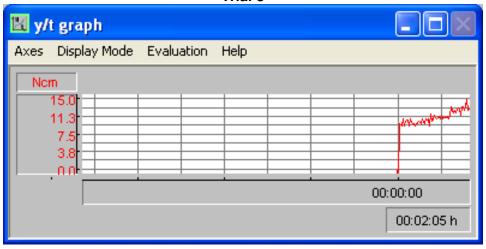


Figure C.3: Ruggedness Trials

Trial 7



Trial 8



Trial 9

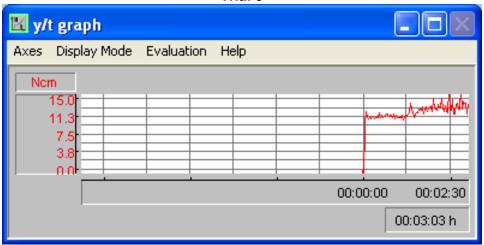
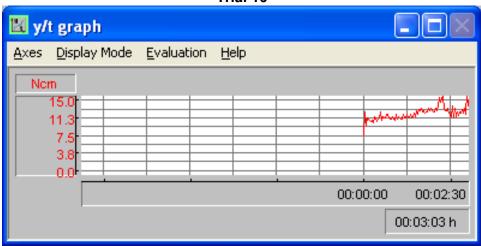
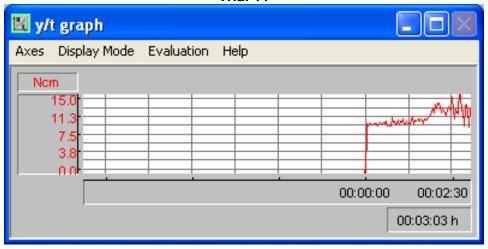


Figure C.4: Ruggedness Trials

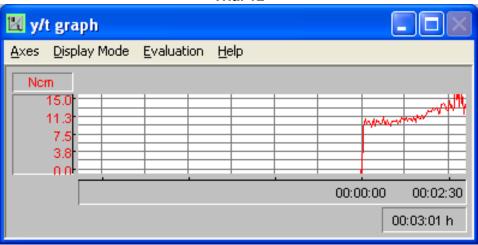
Trial 10



Trial 11



Trial 12



APPENDIX D RESULTS OF CAT RUGGEDNESS TESTING

55/65 23/27 40/60 55/65 20/30

Parameter	Values		Test No.								
	<u>-</u>	Low (L)	-	0	က	4	2	9	7	ω	
1. Cure Time (60min)	2	-5	н	7	٦	т	٦	н	н	_	min
2. Cure Temp.(25°C)	2	-5	т	н	7	٦	н	7	н	٦	ပ
3. Humidity (50%)	10	-10	Н	Н	Н	7	7	Н	7	٦	%
4. Test Time (1min)	2	9-	7	н	н	н	7	7	н	٦	s
5. Test Temp. (25°C)	2	9-	Н	T	Н	I	H	7	T	٦	ပ
6. Test Duration (1min)	2	9-	Τ	Н	L	I	H	Н	T	٦	s

CAT: Cohesion Abrasion Test (French WTAT): short term

CEL#:	10-17749		LAB #:		Date Tester_	Apr-07		M4: Rugged	M4: Ruggedness Evaluation # 1	
Project Name:	ne:	Slurry/Micro	Slurry/Micro Mix Design		Tested By:	크		1) apply tack co	1) apply tack coat to disc and break emulsion	ion
Aggregate:	Type 3			Emulsion: MSE	LMCQS-1h	-		2)record weight	2)record weight of specimen after cure, before so	efore s
Source:	LOPKE			Source:	VSS Emultech	£		3)cover test spe	3) cover test specimen with water	
Emulsion m	Emulsion mid-range target:	let:	11.0					4) abrade for time below	ne below	
Pre-wet wa	Pre-wet water mid-range target:	target:	16.0					5) rinse debris w	5) rinse debris with 1000ml of water	
Additive mid	Additive mid-range target:	::	1.0	1.0 Additive:	cement type 2	2		6)carefully pat dry with towel	dry with towel	
Additive mid	Additive mid-range target:	::	00.00	0.00 Additive:	Aluminum sulfate	lfate		7) record weight after test	t after test	
Additive mid	Additive mid-range target:	:t:		Additive:						
Additive mid	Additive mid-range target:	÷		Additive:						
						Curing Conditions:	ditions:			
			Cohes.Abra	Cohes. Abrasion w/wheels				Control	Eval#1	
%	material		weights,g			Temperature, ℃	re, °C	25	27 ℃	
1	aggregate		1350.0	agg		Temperature, °F	re, ℉	77	80.6 ⊬	
1.0	1.0 cement / lime	Ф	13.5	cement						
	Other:				_	Humidity, %	9	20	09	
16.0	16.0 water		216.0	water				•		
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate		soaking pe	Soaking period before testing	testing	see below	
11.0	11.0 emulsion (target)	rget)	148.5	emulsion						
	Other:				<u> </u>	Sompaction	n w/ roller i	Compaction w/ roller immediately before testing		NONE
_∀	Cure	Cure	Cure	Test time	Test	Test	В	C=A-B		
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss		
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g		
1864.2	65	27.0	09	55	30	55	1533.3	330.9		
1875.7	65	27.2	09	55	30	55	1617.1	258.6		
1866.6	65	26.8	09	55	31	55	1563.8	302.8		
	İ									

CEL#:	10-17749		LAB#:		Date Tester	Apr-07		M4: Ruggedness Evaluation # 2	Evaluation # 2
Project Name:	me:	Slurry/Micro	Slurry/Micro Mix Design		Tested By:	크		1) apply tack coat to di	1) apply tack coat to disc and break emulsion
Aggregate: Type	: Type 3			Emulsion: MS	MSE LMCQS-1h	P		2) record weight of spe	2) record weight of specimen after cure, before so
Source:	LOPKE			Source:	ERGON			3) cover test specimen with water	with water
Emulsion n	Emulsion mid-range target:	yet:	11.0					4) abrade for time below	W
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					5) rinse debris with 1000ml of water	00ml of water
Additive mi	Additive mid-range target:	≯ t:	1.0	1.0 Additive:	cement type 2	2		6) carefully pat dry with towel	towel
Additive mi	Additive mid-range target:	≯ :	0.0	0.0 Additive:	Aluminum sulfate	ulfate		7) record weight after test	est
Additive mi	Additive mid-range target:) t:		Additive:			_		
Additive mi	Additive mid-range target:	≯ t:		Additive:			_		
						Curing Conditions:	ditions:		
			Cohes.Abra	Cohes. Abrasion w/wheels				Control Eval#2	
%	material		weights,g			Temperature, °C	re, °C	25 27	.7 °C
!	aggregate		1350.0	agg		Temperature, ⁰F	re, ⁰F	77 80.6	ું 9
1.0	1.0 cement / lime	Je	13.5	cement	. ,				
	Other:					Humidity, %	%	9 09	09
16.0	16.0 water		216.0	water	•				
ე.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate	te	Soaking pe	Soaking period before testing		see below
11.0	11.0 emulsion (target)	arget)	148.5	emulsion	. ,				
	Other;					Compaction	n w/ roller i	Compaction w/ roller immediately before testing	sting NONE
_<	Cure	Cure	Cure	Test time	Test	Test	В	C=A-B	
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss	
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g	
1884.2	2 55	26.8	61	65	20	65	1520.1	364.1	
1869.1	1 55	26.9	60	65	20	65	1589.1	280	
1870	55	27.0	59	65	20	65	1537.8	332.2	
ı									

CEL#:	10-17749		LAB#:		Date Tester	Apr-07		M4: Rugg	M4: Ruggedness Evaluation # 3	#3
Project Name:	ne:	Slurry/Micro	Slurry/Micro Mix Design		Tested By: LH	H		1) apply tack	1) apply tack coat to disc and break emulsion	mulsion
Aggregate:	Type 3			Emulsion: MSE	MSE LMCQS-1h	h		2) record wei	2)record weight of specimen after cure, before so	re, before s
Source:	LOPKE			Source:	VSS Emultech	ltech		3) cover test	3)cover test specimen with water	
Emulsion m	Emulsion mid-range target:	jet:	11.0					4) abrade for time below	time below	
Pre-wet wai	Pre-wet water mid-range target:	target:	16.0					5) rinse debri	5) rinse debris with 1000ml of water	
Additive mic	Additive mid-range target:	;;	1.0	1.0 Additive:	cement type 2	2		6) carefully pa	6)carefully pat dry with towel	
Additive mic	Additive mid-range target:	;;	0.0	0.0 Additive:	Aluminum sulfate	ulfate		7) record weight after test	ght after test	
Additive mid	Additive mid-range target:) ; :		Additive:						
Additive mic	Additive mid-range target:	;;		Additive:						
						Curing Conditions:	ditions:			
			Cohes.Abra	Cohes. Abrasion w/wheels				Control	Eval#3	
%	material		weights,g			Temperature, °C	æ, °C	25	23 င	
1	aggregate		1350.0	agg		Temperature, ⁰F	ʻe, ℉	77	73.4 ⁰F	
1.0	1.0 cement / lime	Ф	13.5	cement	ı					
	Other:					Humidity, %	,	20	09	
16.0	16.0 water		216.0	water						
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate		Soaking pe	Soaking period before testing	testing	see below	
11.0	11.0 emulsion (target)	ırget)	148.5	emulsion	•					
	Other:					Compactio	n w/ roller i	nmediately	Compaction w/ roller immediately before testing	NONE
					1					
⋖	Cure	Cure	Cure	Test time	Test	Test	 B	C=A-B		
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss		
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g		
1879.2	55	23.0	09	65	30	55	1554.6	324.6		
1880.5	55	23.0	09	65	30	55	1610	270.5		
1863.8	55	23.1	09	65	30	55	1581.7	282.1		
1										

CEL#:	10-17749		LAB#:		Date Tester	Apr-07		M4: Ruga	M4: Ruggedness Evaluation # 4	# 4
Project Name:	me:	Slurry/Micro	Slurry/Micro Mix Design		Tested By: LH	_ =		1) apply tack	1)apply tack coat to disc and break emulsion	nulsion
Aggregate:	Type 3			Emulsion: MSE	MSE LMCQS-1h	h		2) record wei	2)record weight of specimen after cure, before so	e, before s
Source:	LOPKE			Source:	VSS Emultech	ltech		3) cover test	3)cover test specimen with water	
Emulsion n	Emulsion mid-range target:	yet:	11.0					4) abrade for time below	time below	
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					5) rinse debri	5) rinse debris with 1000ml of water	
Additive mi	Additive mid-range target:	¥:	1.0	.0 Additive:	cement type 2	2		6)carefully pa	6)carefully pat dry with towel	
Additive mi	Additive mid-range target:	¥:	0.0	0.0 Additive:	Aluminum sulfate	ılfate		7) record wei	7) record weight after test	
Additive mi	Additive mid-range target:	¥:		Additive:						
Additive mi	Additive mid-range target:	¥:		Additive:						
				ī		Curing Conditions:	ditions:			
			Cohes.Abra	Cohes. Abrasion w/wheels				Control	Eval#4	
%	material		weights,g			Temperature, ℃	.e, ℃	25	23 င	
1	aggregate		1350.0	agg	-	Temperature, °F	'e, ⁰F	77	73.4 ∘⊦	
1.0	1.0 cement / lime	je Je	13.5	cement						
	Other:					Humidity, %	,	20	40	
16.0	16.0 water		216.0	water						
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate		Soaking pe	Soaking period before testing	testing	see below	
11.0	11.0 emulsion (target)	arget)	148.5	emulsion	1					
	Other:					Compactio	n w/ roller in	nmediately	Compaction w/ roller immediately before testing	NONE
⋖	Cure	Cure	Cure	Test time	Test	Test		C=A-B		
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss		
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g		
1845.1	65	22.9	39	65	29	65	1600.3	244.8		
1868.8	3 65	23.1	42	65	30	65	1598.8	270		
1865.4	1 65	23.0	39	64	30	65	1579	286.4		

CEL#:	10-17749		LAB#:		Date Tester	Apr-07		M4: Rugge	M4: Ruggedness Evaluation # 5	# 2
Project Name:	me:	Slurry/Micro	Slurry/Micro Mix Design		Tested By:	크		1)apply tack o	1)apply tack coat to disc and break emulsion	mulsion
Aggregate:	: Type 3			Emulsion: MSE	MSE LMCQS-1h	,		2)record weig	2)record weight of specimen after cure, before so	re, before s
Source:	LOPKE			Source:	VSS Emultech	h.		3)cover test s	3)cover test specimen with water	
Emulsion n	Emulsion mid-range target:	yet:	11.0					4)abrade for time below	ime below	
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					5)rinse debris	5)rinse debris with 1000ml of water	
Additive mi	Additive mid-range target:	≯ t:	1.0	1.0 Additive:	cement type 2	2		6)carefully pa	6)carefully pat dry with towel	
Additive mi	Additive mid-range target:	≯ :	0.0	0.0 Additive:	Aluminum sulfate	lfate		7)record weight after test	iht after test	
Additive mi	Additive mid-range target:	¥:		Additive:						
Additive mi	Additive mid-range target:	≯ t:		Additive:						
					O	Curing Conditions:	ditions:			
			Cohes.Abra	Cohes. Abrasion w/wheels				Control	Eval#5	
%	material		weights,g		–	Temperature, °C	e,°C	25	27 ℃	
1	aggregate		1350.0	agg	<u>-</u>	Temperature, ⁰F	e, ℉	77	80.6 ⊬	
1.0	1.0 cement / lime	Je	13.5	cement						
	Other:					Humidity, %	,	20	40	
16.0	16.0 water		216.0	water						
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate	<u>.</u>	oaking pe	Soaking period before testing	testing	see below	
11.0	11.0 emulsion (target)	arget)	148.5	emulsion						
	Other:				<u>.</u>	compaction	יי w/ roller iי	nmediately b	Compaction w/ roller immediately before testing	NONE
_∢	Cure	Cure	Cure	Test time	Test	Test	В	C=A-B		
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss		
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g		
1852.2	2 55	26.9	44	55	30	65	1604.5	247.7		
1863.4	1 55	27.1	44	55	30	65	1648.1	215.3		
1870	55	27.1	44	55	31	65	1494.1	375.9		
į.										

CEL#:	10-17749		LAB#:		Date Tester_	Apr-07		M4: Rugge	M4: Ruggedness Evaluation # 6	9#
Project Name:	me:	Slurry/Micro	Slurry/Micro Mix Design		Tested By:	크		1)apply tack o	1)apply tack coat to disc and break emulsion	nulsion
Aggregate:	Type 3			Emulsion: MSE	MSE LMCQS-1h	J		2)record weig	2)record weight of specimen after cure, before so	e, before s
Source:	LOPKE			Source:	VSS Emultech	£		3)cover test s	3)cover test specimen with water	
Emulsion n	Emulsion mid-range target:	jet:	11.0					4)abrade for time below	ime below	
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					5)rinse debris	5)rinse debris with 1000ml of water	
Additive mi	Additive mid-range target:	;;	1.0	1.0 Additive:	cement type 2	2		6)carefully pa	6)carefully pat dry with towel	
Additive mi	Additive mid-range target:	;;	0.0	0.0 Additive:	Aluminum sulfate	lfate		7)record weight after test	ht after test	
Additive mi	Additive mid-range target:	;;		Additive:						
Additive mi	Additive mid-range target:	;;		Additive:						
					O _I	Curing Conditions:	ditions:			
			Cohes.Abra	Cohes. Abrasion w/wheels				Control	Eval#6	
%	material		weights,g			Temperature, ℃	e, ℃	25	23 င	
:	aggregate		1350.0	agg		Temperature, ⁰F	'e, °F	77	73.4 ℉	
1.0	1.0 cement / lime	е	13.5	cement						
	Other:					Humidity, %	,0	20	09	
16.0	16.0 water		216.0	water						
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate	U	soaking pe	Soaking period before testing	testing	see below	
11.0	11.0 emulsion (target)	ırget)	148.5	emulsion						
	Other:				<u> </u>	Sompaction	א roller iו w/	nmediately b	Compaction w/ roller immediately before testing	NONE
<	Cure	Cure	Cure	Test time	Test	Test	В	C=A-B		
Original	Time	Temp	Humidity	in pan bfore	Temp	Duraction	Final	Loss		
Wt, g	minutes			abras, sec		sec	Wt, g	Wt, g		
1913	3 65	22.6	58	55	20	65	1564.7	348.3		
1882.1	65	23.2	58	55	21	65	1531	351.1		
1897.9	65	23.2	59	55	21	65	1553.2	344.7		

Aggregate: Tipe 3 bit (a) (b) (b) (b) (c) (c) (c) (c) (c) (c) (c) (c) (c) (c	CEL#: 10	10-17749	LAB#:	Date Tester	Apr-07	M4: Rugge	M4: Ruggedness Evaluation # 7	
Emulsion: MSE LMCQS-1h Source: VSS Emultech 1.0 Additive: cement type 2 1.0 Additive: Aluminum sulfate Additive: Additive: Aluminum sulfate Additive: Additive: Coring Conditions: Cohes. Abrasion w/wheels weights,g 1350.0 agg 1350.0 water tate 0.0 Aluminum sulfate Soaking period before ret) 148.5 emulsion Compaction w/ roller in	Project Name		ro Mix Design	Tested By:	H	1)apply tack o	1)apply tack coat to disc and break emulsion	sion
Source: VSS Emultech	Aggregate: T	ype 3		LMCQS-1h		2)record weig	2)record weight of specimen after cure, before so	efore s
t: 11.0 arget: 16.0 1.0 Additive: cement type 2 0.0 Additive: Aluminum sulfate Additive: Additive: Additive: Cohes.Abrasion w/wheels weights,g 1350.0 agg 13.5 cement 13.5 cement 13.5 cement 13.5 cement 148.5 emulsion Compaction w/ roller in		OPKE	Source:	VSS Emultech		3)cover test s	3)cover test specimen with water	
arget: 16.0 Additive: cement type 2 0.0 Additive: Aluminum sulfate Additive: Additive: Cohes. Abrasion w/wheels weights,g Temperature, c 1350.0 agg 13.5 cement 216.0 water get 0.0 Aluminum sulfate ret) 148.5 emulsion Compaction w/ roller in	Emulsion mid-	-range target:	11.0			4)abrade for time below	ime below	
1.0 Additive: cement type 2 Additive: Aluminum sulfate Additive: Aluminum sulfate Cohes.Abrasion w/wheels weights,g 1350.0 agg 13.5 cement 13.5 cement 216.0 water 216.0 water age 216.0 Aluminum sulfate 0.0 Aluminum sulfate 148.5 emulsion Compaction w/ roller in	Pre-wet water	mid-range target:	16.0			5)rinse debris	5)rinse debris with 1000ml of water	
0.0 Additive: Aluminum s Additive:	Additive mid-ra	ange target:	1.0 Additive:	cement type 2		6)carefully pa	6)carefully pat dry with towel	
Additive: Additive: Cohes.Abrasion w/wheels weights,g 1350.0 agg 13.5 cement 13.5 cement 216.0 water fate 0.0 Aluminum sulfate yet) 148.5 emulsion	Additive mid-ra	ange target:	0.0 Additive:	Aluminum sulfa	ıte	7)record weight after test	iht after test	
Additive: Cohes.Abrasion w/wheels weights,g 1350.0 agg 13.5 cement 216.0 water ate 0.0 Aluminum sulfate 9et) 148.5 emulsion	Additive mid-ra	ange target:	Additive:					
Cohes.Abrasion w/wheels weights.g aggregate 1350.0 agg 1.0 cement / lime 13.5 cement Other: 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: 148.5 emulsion	Additive mid-ra	ange target:	Additive:					
Cohes. Abrasion w/wheels material weights,g aggregate 1350.0 agg 1.0 cement / lime 13.5 cement Other: 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Coher.				Cn	ring Conditions:			
material weights,g aggregate 1350.0 agg 1.0 cement / lime 13.5 cement Cother: 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Other:			Cohes. Abrasion w/wheels			Control	Eval#7	
aggregate 1350.0 agg 1.0 cement / lime 13.5 cement Other: 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Other:		aterial	weights,g	Tel	mperature, °C	25	27 ℃	
13.5 cement 216.0 water 0.0 Aluminum sulfate 148.5 emulsion		ggregate		Те	mperature, ⁰F	77	80.6 ∘⊬	
216.0 water 0.0 Aluminum sulfate 148.5 emulsion	1.0 ce	ement / lime						
216.0 water 0.0 Aluminum sulfate 148.5 emulsion	Ō	ther:		뀌	midity, %	20	40	
0.0 Aluminum sulfate 148.5 emulsion	16.0 wa	ater						
148.5 emulsion	0.0 AI	luminum sulfate	0.0 Aluminum sulfate		aking period befo	re testing	see below	
	11.0 er	mulsion (target)	148.5 emulsion					
	Ō	ther:		<u>ပိ</u>	mpaction w/ rolle	r immediately b		NONE
]				

C=A-B	Loss	Wt, g	290.1	264.7	340.7
В	Final	Wt, g	1550.4	1627.6	1525
Test	Duraction Final	sec	55	55	55
Test	Temp		20	20	20
Test time	in pan bfore	abras, sec	99	65	65
Cure	Humidity		40	40	38
Cure	Temp		26.7	26.9	26.9
Cure	Time	minutes	65	65	65
V	Original	Wt, g	1840.5	1892.3	1865.7

Emulsion: MSE LMCQS-1 Source: VSS Emulte 11.0 16.0 10.0 Additive: Aluminum sulfate 13.5 cement 16.0 water 0.0 Aluminum sulfate 48.5 emulsion 16.0 water 16.0 water 16.0 water 16.0 agg 13.5 cement 16.0 agg 16.0	LAB #: Date Tester	Apr-07	M4: Ruggedness Evaluation # 8
Cure Type 3 Emulsion: MSE LMCQS-1			1)apply tack coat to disc and break emulsion
e: LOPKE sion mid-range target: 11.0 et water mid-range target: 16.0 e mid-range target: 10.0 Additive: cement type e mid-range target: 0.0 Additive: Add	MSE		2) record weight of specimen after cure, before so
11.0 et water mid-range target:	'		3)cover test specimen with water
the water mid-range target: / / / / / / / / / /	11.0		4) abrade for time below
e mid-range target: 1.0 Additive: cement type /e mid-range target: 0.0 Additive: Additive: /e mid-range target: Additive: Additive: /e mid-range target: Cohes.Abrasion w/wheels Additive: /e mid-range target: Cohes.Abrasion w/wheels Additive: /e mid-range target: Cohes.Abrasion w/wheels Additive: /e mid-range target: 1350.0 agg /e mid-range target: 148.5 emulsion /e mulsion (target) 148.5 emulsion /e mulsion (target) 148.5 emulsion /e minutes Temp Humidity in pan bfore Temp /e minutes 23.0 40 55 20 /e mid-range target: 20 20 20 20 <td></td> <td></td> <td>5) rinse debris with 1000ml of water</td>			5) rinse debris with 1000ml of water
e mid-range target: 0.0 Additive: Additive: /e mid-range target: Additive: Additive: /e mid-range target: Cohes.Abrasion w/wheels /e mid-range target: Cohes.Abrasion w/wheels /e material weights,g - aggregate 1350.0 agg 1.0 cement / lime 135.0 agg 1.0 cement / lime 13.5 cement Other: 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate Other: Other: 148.5 emulsion Other: Temp Humidity in pan bfore Temp all Time Temp Humidity in pan bfore Temp minutes 23.0 40 55 20 B80.3 55 20 55 20	,		6)carefully pat dry with towel
Additive: Additive: Additive: Additive: Additive: Additive: Additive: Additive: Cohes. Abrasion w/wheels weights,g aggregate 1350.0 agg 1.0 cement / lime 13.5 cement	,	te	7) record weight after test
Additive: Cohes.Abrasion w/wheels Cohes.Abrasion w/wheels Additive: Cohes.Abrasion w/wheels Additive:	Additive:		
Cohes.Abrasion w/wheels Weights,g Agreegate 1350.0 agg	Additive:		
Cohes. Abrasion w/wheels	Cui	Curing Conditions:	
aggregate	Cohes.Abrasion w/wheels		Control Eval#8
- aggregate 1350.0 agg 1.0 cement / lime 13.5 cement 1.0 cement / lime 13.5 cement 16.0 water 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Cure Text time Text al Time Temp Humidity in pan bfore Temp minutes 23.0 40 55 20 880.3 55 23.0 55 20 888.1 55 23.0 50 50		Temperature, °C	25 23 °C
1.0 cement / lime 13.5 cement Other: Other: O.0 Aluminum sulfate O.0 Aluminum sulfate Other: Other: Cure Cure Test time Test and abras, sec Temp Humidity in pan bfore Temp Temp Humidity in pan bfore Temp Humidity Humidit	agg	Temperature, ⁰F	77 73.4 ℉
Other:			
16.0 water 216.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Other: Test time Test al Time Temp Humidity in pan bfore Temp B80.3 55 23.0 40 55 20 B881 55 20 50 50		Humidity, %	50 40
O.0 Aluminum sulfate 0.0 Aluminum sulfate 11.0 emulsion (target) 148.5 emulsion Other: Cure Cure Test time Temp al Time Temp Humidity in pan bfore Temp B80.3 55 23.0 40 55 20 B88.4 55 57 30 55 20			
11.0 emulsion (target) 148.5 emulsion Other: Cure Cure Test time Temp al Time Temp Humidity in pan bfore Temp R80.3 55 23.0 40 55 20 R88.1 55 20 50 50	Aluminum sulfate	Soaking period before testing	testing see below
Cure Cure Test time Test Cure Cure Test time Temp Humidity in pan bfore Temp minutes Humidity abras, sec 20 B80.3 55 23.0 40 55 20 B88.1 55 23.0 40 55 20			
Cure Cure Cure Test time Temp al Time Temp Humidity in pan bfore Temp minutes abras, sec 23.0 40 55 20 880.3 55 23.0 40 55 20		mpaction w/ roller	Compaction w/ roller immediately before testing NONE
Cure Cure Test time Test al Time Temp Humidity in pan bfore Temp minutes abras, sec 23.0 40 55 20 880.3 55 23.0 40 55 20			
al Time Temp Humidity in pan bfore Temp abras, sec abras, sec 880.3 55 23.0 40 55 20	Cure Test time Test	Test B	C=A-B
minutes abras, sec 880.3 55 23.0 40 55 20 888.1 55 20	Humidity in pan bfore Temp	raction Final	Loss
55 23.0 40 55 20 55 23.0 39 55 20	abras, sec	sec Wt, g	Wt, g
55 20 55 50 55 50 50 50 50 50 50 50 50 50 50	40 55	55 1593.2	287.1
33 33 50	7 39 55 20	55 1531.7	356.4
1884.9 55 22.9 38 55 21 55	38 55	55 1546.4	338.5

2.CAT-Cohesion Abrasion Test: French WTAT, short-term: Mix 4

Parameter 1	. Cure Tiı.	Cure Tem 3	. Humidit	4. Test Tin 5	5. Test Te	6. Test Di	uration			
Test No. 1	5	2℃	60	-5	30	-5	original	final	loss	final loss
	65	27.0	60	55 sec	30	55	1864.2	1533.3	330.9	331
	65	27.2	60	55 sec	30	55	1875.7	1617.1	258.6	259
	65	26.8	60	55 sec	31	55	1866.6	1563.8	302.8	303
Test No. 2	-5	2℃	60	5	20	5	original	final	loss	final loss
	55	26.8	61	65	20	65	1884.2	1520.1	364.1	364
	55	26.9	60	65	20	65	1869.1	1589.1	280.0	
	55	27.0	59	65	20	65	1870.0	1537.8	332.2	332
Test No. 3	-5	-2℃	60	5	30	-5	original	final	loss	final loss
	55	23.0	60	65	30	55	1879.2	1554.6	324.6	
	55	23.0	60	65	30	55	1880.5		270.5	
	55	23.1	60	65	30	55	1863.8	1581.7	282.1	
		_0								
Test No. 4	5	-2℃	40	5	30	5	original	final	loss	final loss
	65	22.9	39	65	29	65	1845.1	1600.3	244.8	245
	65	23.1	42	65	30	65	1868.8	1598.8	270.0	270
	65	23.0	39	64	30	65	1865.4	1579.0	286.4	286
Test No. 5	-5	2℃	40	-5	30	5	original	final	loss	final loss
	55	26.9	44	55	30	65	1852.2	1604.5	247.7	248
	55	27.1	44	55	30	65	1863.4	1648.1	215.3	215
	55	27.1	44	55	31	65	1870.0	1494.1	375.9	376
Test No. 6	5	-2℃	60	-5	20	5	original	final	loss	final loss
7001740.0	65	22.6	58	55	20	65	1913.0	1564.7	348.3	
	65	23.2	58	55	21	65	1882.1		351.1	
	65	23.2	59	55	21	65	1897.9	1553.2	344.7	
									•	
Test No. 7	5	2℃	40	5	20	-5	original	final	loss	final loss
	65	26.7	40	65	20	55	1840.5	1550.4	290.1	290
	65	26.9	40	65	20	55	1892.3	1627.6	264.7	265
	65	26.9	38	65	20	55	1865.7	1525.0	340.7	341
Test No. 8	-5	-2℃	40	-5	20	-5	original	final	loss	final loss
	55	23.0	40	55	20	55	1880.3	1593.2	287.1	
	55	22.7	39	55	20	55	1888.1	1531.7	356.4	
	55	22.9	38	55	21	55	1884.9	1546.4	338.5	
est method	60 min	25°C	50%	60 sec	25°C	60 sec				

curing time curing temp curing humidity soaking time abrasion water abrasion time

55/65 23/27 40/60 55/65 20/30 55/65 n S S S S ω \mathbf{I} I ᆈェ 9 ェ エ ェ 2 ᅟᅵᄑ エ エエ I エ 4 ェ I ェ က N I I I Test No. CAT: Cohesion Abrasion Test (French WTAT): short term I エエ I 4 4 က် က် က် Low (L) Values High (H) 2 2 2 2 2 6. Test Duration (1min) 1. Cure Time (60min) 4. Test Time (1min) 5. Test Temp. (25°C) 2. Cure Temp.(25°C) 3. Humidity (50%) Parameter

		e soaking																	NONE		C=A-B	Loss	Wt, g time ck	1.2 241.5 1:05	3.1 265.5 1:05	1.6 273.3 1:05		
Evaluation # 1	1) apply tack coat to disc and break emulsion	2) record weight of specimen after cure, before soaking	vith water		Iml of water	lowel	st				S		<u></u>				see below				Temp B	of SOAK Final	water Wt, g	30 1391.2	30 1368.1	30 1361.6		
M5: Ruggedness Evaluation#1	ply tack coat to disc	cord weight of spec	3)cover test specimen with water	4)abrade for time below	5) rinse debris with 1000ml of water	6)carefully pat dry with towel	7)record weight after test				trol Eval#1		77 80.6		09 09				Compaction w/ roller immediately before testing		king Abrasion	od time	before test	55 sec 55 sec	55 sec 55 sec	55 sec 55 sec		
		<u>2)rec</u>	3)co	4)ab	5) rin	6)ca	7)rec	1	Ī	nditions:	Control	J. i	ure,°F		%		Soaking period before testing		on w/ roller imme		Final Soaking	Humidity Period	befo	59 55	59 55	59 55	30 င	
Mar-08	크					e 2	sulfate			Curing Conditions	F	remperature, c	Temperature, °F		Humidity, %		Soaking p		Compaction		Final	Temp		27	27	27	Temp of test water:	
_ Date Tester_	_Tested By:	MICRO	ERGON			cement type 2	Aluminum sulfate					_			-0-0-0-0-		Ф		-0000	lesses	End	Clock	Time	8:55	9:02	9:15	Temp o	
		Emulsion: MSE	Source:	, ,		0.5 Additive:	0.00 Additive:	Additive:	Additive:	•	asion w/wheels		agg	cement		water	0.0 Aluminum sulfate	emulsion			Initial	Humidity		09	59	59		
LAB#:	Slurry/Micro Mix Design			10.0	8.0	0.5	0.00				Cohes.Abrasion	weights, g	1350.0	6.8		108.0	0.0	135.0			Initial	Temp		27.4	26.8	26.9		
	Slurry/Micro			get:	e target:	et:	et:	et:	et:					ne			sulfate	'arget)			Start	Clock	Time	7:50	8:00	8:10		
10-17749	ne:	Type 3	TEXAS	Emulsion mid-range target:	Pre-wet water mid-range target:	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:		-0.5	IIIatellal	aggregate	0.5 cement / lime	Other:	8.0 water	0.0 Aluminum sulfate	10.0 emulsion (target)	Other:		Cure	Time	minutes	. 65	65	65		
CEL#:	Project Name:	Aggregate: Type	Source:	Emulsion m	Pre-wet wa	Additive mic	Additive mic	Additive mic	Additive mic		ò	/0	1	0.5		8.0	0.0	10.0			Α	Original	Wt, g	1632.7	1633.6	1634.9		

	ion	efore soaking																	NONE	C=A-B
M5: Ruggedness Evaluation #2	1)apply tack coat to disc and break emulsion	2)record weight of specimen after cure, before soaking	3)cover test specimen with water	4)abrade for time below	5)rinse debris with 1000ml of water	6)carefully pat dry with towel	7)record weight after test				Eval#2	27 ℃	₩ 9.08		09		see below		before testing	Abrasion Temp B
M5: Rugo	1)apply tack	2)record we	3)cover test	4)abrade for	5)rinse debr	6)carefully p	7)record we				Control	25	77		20		e testing		immediately	Soaking
Mar-08	ㅂ						te			Curing Conditions:		Temperature, ℃	Temperature, ℉		Humidity, %		Soaking period before testing		Compaction w/ roller immediately before testing	Final Final
Date Tester	Tested By:	MICRO	ERGON			cement type 2	Aluminum sulfate			Cu	<u>s</u>		Ter		Hū				ပိ	End
		Emulsion:	Source:			0.5 Additive:	0.00 Additive:	Additive:	Additive:	•	Cohes. Abrasion w/wheels		agg	cement		water	0.0 Aluminum sulfate	135.0 emulsion		Initial
LAB#:	Slurry/Micro Mix Design			10.0	8.0	0.5	0.00				Cohes.Abra	weights,g	1350.0	6.8		108.0	0.0	135.0		Initial
	Slurry/Micro			get:	e target:	et:	et:	et:	et:					ne			sulfate	arget)		Start
-#: 10-17749	Project Name:	Aggregate: Type 3	Source: TEXAS	Emulsion mid-range target:	Pre-wet water mid-range target:	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:			% material	aggregate	0.5 cement / lime	Other:	8.0 water	0.0 Aluminum sulfate	10.0 emulsion (target)	Other:	Cure
CEL#:	Proj	Agg	Sou	Em	Pre-	Add	Add	Add	Add											⋖

⋖	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	<u>a</u>	C=A-B
Original	Time	Clock	Temp	Humidity	Clock	Temp	Humidity	Period	time	of SOAK Final	Final	Loss
Wt, g	minutes	Time			Time			before test		water	Wt, g	Wt, g
1572.8	55	12:10	27.1	09	13:05	27	59	65 sec	65 sec	20	1397	175.8
1613.1	55	12:25	26.6	09	13:20	27	80	65 sec	95 sec	20	1375.2	237.9
1596.5	55	12:45	26.8	09	13:40	27	59	65 sec	65 sec	20	1340.9	255.6
					Temp of	Temp of test water:		20 ℃				
							989 ⇔	₽				

CEL#:	10-17749		LAB #:		Date Tester	Mar-08		M5: Rug	M5: Ruggedness Evaluation # 3	valuation	#3	
Project Name:		Slurry/Micro	Slurry/Micro Mix Design		Tested By: LH	LH		1)apply tack	1)apply tack coat to disc and break emulsion	and break e	emulsion	
Aggregate: Type 3	Type 3			Emulsion:	MICRO			2)record we	2)record weight of specimen after cure, before soaking	imen after cu	ıre, before s	oaking
Source:	TEXAS		3,	Source:	ERGON'			3)cover tes	3)cover test specimen with water	vith water		
Emulsion m	Emulsion mid-range target:	et:	10.0					4)abrade fc	4)abrade for time below			
Pre-wet wat	Pre-wet water mid-range target:	target:	8.0					5)rinse deb	5)rinse debris with 1000ml of water	ml of water		
Additive mic	Additive mid-range target:	نن	0.5	0.5 Additive:	cement type 2	2		6)carefully	6)carefully pat dry with towel	owel		
Additive mic	Additive mid-range target:	ن ن	0.00	0.00 Additive:	Aluminum sulfate	ulfate		7)record we	7)record weight after test);		
Additive mic	Additive mid-range target:	ټ		Additive:								
Additive mic	Additive mid-range target:	ij	•	Additive:								
						Curing Conditions:	nditions:					
			Cohes. Abrasion w/wheels	ion w/whee	SI6			Control	Eval#3			
%	material		weights,g			Temperature, °C	ıre, °C	25	23	ပွ		
1	aggregate		1350.0	agg	•	Temperature, ⁰F	ıre, ℉	77	73.4	ĥ		
0.5	0.5 cement / lime	o.	6.8	cement								
	Other:					Humidity, %	%	50	60			
8.0	8.0 water	•	108.0	water	,							
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate		Soaking pe	Soaking period before testing	e testing	q əəs	see below		
10.0	10.0 emulsion (target)	rget)	135.0	135.0 emulsion							_	
	Other:					Compactio	n w/ roller	Compaction w/ roller immediately before testing	before test	ing	ON	NONE
٨	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	<u>B</u>	C=A-B
	Ë	700	F	11:00:00:1	700	F	4:17:25:1	70.		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	- ! L	000

∢	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	В	C=A-B
Original	Time	Clock	Temp	Humidity	Clock	Temp	Humidity	Period	time	of SOAK Final	Final	Loss
Wt, g	minutes	Time			Time			before test		water	Wt, g	Wt, g
1600.8	55	9:30	22.7	59	10:25	23	59	65 sec	55 sec	30	1251.3	349.5
1619.9	55	9:45	22.7	09	10:40	23	59	65 sec	55 sec	30	1304.1	315.8
1580.8	55	10:00	23.1	59	10:55	23	59	65 sec	55 sec	30	1268.8	312.0

Temp of test water: 30 °C 86 °F

CEL#:	10-17749		LAB#:		Date Tester	Mar-08		M5: Rug	M5: Ruggedness Evaluation # 4	valuatio	n #4	
Project Name:	ame:	Slurry/Micro	Slurny/Micro Mix Design		Tested By: LH	ㅗ.		1)apply tac	1)apply tack coat to disc and break emulsion	and break	emulsion	
Aggregat	Aggregate: Type 3		ш	Emulsion:	MICRO			2)record we	2)record weight of specimen after cure, before soaking	nen after c	ure, before	soaking
Source:	TEXAS		0,	Source:	ERGON			3)cover tes	3)cover test specimen with water	ith water		
Emulsion	Emulsion mid-range target:	jet:	10.0					4)abrade fc	4)abrade for time below			
Pre-wet w	Pre-wet water mid-range target:	e target:	8.0					5)rinse deb	5)rinse debris with 1000ml of water	nl of water		
Additive n	Additive mid-range target:	¥:	0.5	0.5 Additive:	cement type 2	2		6)carefully	6)carefully pat dry with towel	owel		
Additive n	Additive mid-range target:	≯:	0.00	0.00 Additive:	Aluminum sulfate	ılfate		7)record we	7)record weight after test	+		
Additive n	Additive mid-range target:	.; ∃:		Additive:								
Additive n	Additive mid-range target:	¥:	1	Additive:								
		-				Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	ion w/whee	Slé			Control	Eval#4			
%	material		weights,g		_	Temperature, °C	re, °C	25	23 °C	ပွ		
1	aggregate	•	1350.0	agg		Temperature, °F	re, ℉	77	73.4	ĥ		
0	0.5 cement / lime	je Pi	6.8	cement								
	Other:					Humidity, %	%	20	40			
8	8.0 water	!	108.0	water							ļ	
0	0.0 Aluminum sulfate	ulfate	0.0	3.0 Aluminum sulfate		Soaking pe	Soaking period before testing	testing	see below	еюм		
10	10.0 emulsion (target)	arget)	135.0	135.0 emulsion							ĺ	
	Other:				<u> </u>	Sompaction	n w/ roller i	immediatel)	Compaction w/ roller immediately before testing	ng	N	NONE
Δ.	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	<u>B</u>	C=A-B

C=A-B	inal Loss	Wt, g Wt, g	1259.2 374.0	1277.8 354.5	1050
Temp B	of SOAK Final	water	30	30	08
Abrasion	time		65 sec	65 sec	65 cec
Soaking	Period	before test	e5 sec	65 sec	200 29
Final	Humidity		40	40	40
Final	Temp		23	23	23
End	Clock	Time	11:25	11:40	12.00
Initial	Humidity		40	40	40
Initial	Temp		22.9	23.0	080
Start	Clock	Time	10:20	10:35	10.55
Cure	Time	minutes	65	65	6.5
⋖	Original	Wt, g	1633.2	1632.3	1635 1

30 ර සි 98

Temp of test water:

Project Name: Slurry/Micro Mix Design Tested By: LH 1)apply tack coat to disc and break emulsion Aggregate: Type 3 Emulsion: MICRO 2)record weight of specimen after cure, before soakin Source: TERGON 3)ouver test specimen with water Apply tack coat to disc and break emulsion Emulsion mid-range target: 10.0 Apply and the water Apply tack specimen with water Additive mid-range target: 0.5 Additive: Additive: Additive: Additive: Additive mid-range target: Additive: Additive	Tested By: LH 1)apply tack coat to disc and break emulsion MICRO 2)record weight of specimen after cure, before 2)record weight of time below 2)record weight after test	CEL#: 10-17749	LAB#:	Date Tester —	Mar-08	M5: Ruggednes	M5: Ruggedness Evaluation # 5	
Emulsion: MICRO	Emulsion: MICRO		cro Mix Design	Tested By:	Н	1)apply tack coat to	disc and break emulsion	
Source: ERGON Source: ERGON Solower test specimen with water 10.00 Source: 8.00 Additive: 8.00 Additive: Aluminum sulfate Cohes Abrasion w/wheels Additive: Cohes Abrasion w/wheels Cohes Abrasion w/wheels Additive: Additive	End ON A) Source rest specimen with water arget: ERGON 4) abrade for time below arget in the below arget in the below arget in the below sare in the below and arget: 4) abrade for time below arget in the below arget in the below arget in the below in the below arget in the below ar	Aggregate: Type 3	Emulsion:	MICRO		2)record weight of s	pecimen after cure, before soakin	
t: 10.0 arget: 8.0 O.00 Additive: cement type 2 O.00 Additive: Aluminum sulfate O.00 Additive: Additive: Aluminum sulfate O.00 Additive: Additive: Aluminum sulfate Additive: Additive: Curing Conditions: Control Eval#5 Weights, G 1350.0 agg Cohes. Abrasion w/wheels Weights, G 1350.0 water 108.0 water O.0 Aluminum sulfate Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	t: 10.0 arget: 8.0 O.5 Additive: cement type 2 O.00 Additive: Aluminum sulfate Additive: Aluminum sulfate Cohes. Abrasion w/wheels weights,g weights,g 1350.0 agg Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Additive: Aluminum sulfate Cohes. Abrasion w/wheels Additive: Aluminum sulfate Cohes. Abrasion w/wheels Additive: Aluminum sulfate of Cohes. Abrasion w/wheels Additive: Additive: Abrasion w/wheels Additive: Aluminum sulfate of Cohes. Abrasion w/wheels Additive: Additive: Abrasion w/wheels		Source:	ERGON		3)cover test specim	en with water	
arget: 8.0 0.5 Additive: cement type 2 6)carefully pat dry with 1000ml of water 0.00 Additive: Aluminum sulfate 7)record weight after test	arget: 8.0 0.05 Additive: cement type 2 6)carefully pat dry with towel	Emulsion mid-range target:	10.0			4)abrade for time be	wok	
0.5 Additive: cement type 2 €)carefully pat dry with towel 0.00 Additive: Aluminum sulfate 7)record weight after test Additive: Additive: Additive: Curing Conditions: Cohes.Abrasion w/wheels weights, g Temperature, ℃ 1350.0 agg 6.8 cement 6.8 cement Humidity, % 50 108.0 water 108.0 water 135.0 emulsion 135.0 emulsion Compaction w/ roller immediately before testing See below	0.00 Additive: Additive: Aluminum sulfate 7) record weight after test Cohes. Abras ion w/wheels weights.g Curing Conditions: Control Eval#5 1350.0 agg Temperature, ℃ 25 27 6.8 cement Humidity, % 50 40 108.0 water Soaking period before testing see below fate 0.0 Aluminum sulfate Soaking period before testing see below fet) 135.0 emulsion	Pre-wet water mid-range target:	8.0			5)rinse debris with 1	000ml of water	
0.00 Additive:	0.00 Additive: Additive: Additive: Additive: Curing Conditions: Control Eval#5 Cohes.Abrasion w/wheels weights, g Temperature, € 25 27 C 46.8 cement Temperature, ₹ 77 80.6 ₱ 6.8 cement Humidity, % 50 40 108.0 water Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	Additive mid-range target:	0.5 Additive:	cement type 2		6)carefully pat dry w	ith towel	
Additive: Additive: Curing Conditions: Control Eval#5 Cohes. Abrasion w/wheels Control Eval#5 Cohes. Abrasion w/wheels Control Eval#5 Veights, g	Additive: Cohes.Abrasion w/wheels weights,g 1350.0 agg 6.8 cement 108.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate Additive: Curing Conditions: Control Eval#5 Control Eval#5 Control Eval#5 Control Eval#5 Temperature,	Additive mid-range target:	0.00 Additive:	Aluminum sul	fate	7)record weight afte	r test	
Additive: Curing Conditions: Cohes. Abrasion w/wheels weights, g Curing Conditions: Control Eval#5 Temperature, °F 77 80.6 °F 1350.0 agg Temperature, °F 77 80.6 °F Temperature, °F 77 80.6 °F Humidity, % 50 40 fate 0.0 Aluminum sulfate Soaking period before testing see below fet) 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	Curing Conditions: Cohes.Abrasion w/wheels weights,g 1350.0 agg 6.8 cement 108.0 water 108.0 water 1350.0 emulsion	Additive mid-range target:	Additive:					
Curing Conditions: material weights.g Temperature, °F Control Eval#5 aggregate 1350.0 agg Temperature, °F 77 80.6 P Other: Coment / lime 6.8 cement Lumidity, % 50 40 8.0 water 10.0 Aluminum sulfate Soaking period before testing see below 10.0 emulsion (target) 135.0 emulsion Other: Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	Curing Conditions: material weights,g Temperature, T Control Eval#5 aggregate 1350.0 agg Temperature, T 77 80.6 F Other: Other: Coment / lime 6.8 cement Comperature, T 77 80.6 F B.0 water 10.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking period before testing see below Compaction w/ roller immediately before testing Compaction w/ roller immediately immediately Compaction w/ roller immediately Compaction w/ roller immediately Cou	Additive mid-range target:	Additive:					
material material aggregate weights, g Temperature, C Control Eval#5 0.5 cement / lime 6.8 cement 40 + 8.0 water 10.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking period before testing see below 10.0 emulsion (target) 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Eval#5	material material aggregate weights,g Temperature, C Control agg Eval#5 0.5 cement / lime of their 6.8 cement 1350.0 agg Aluminum sulfate 108.0 water Humidity, % 50 40 0.0 Aluminum sulfate of their immediately before testing 135.0 emulsion Soaking period before testing see below 0.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Aluminum			O	uring Conditions:			
material material aggregate weights,g Temperature, ℃ Z5 27 ℃ 0.5 cement / lime 6.8 cement F 77 80.6 F F Other: Other: Humidity, % 50 40 F 8.0 water 0.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking period before testing see below F 10.0 emulsion (target) 135.0 emulsion emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Age below	material aggregate weights,g Temperature, ℃ 25 27 ℃ 0.5 cement / lime 6.8 cement Cement Humidity, % 50 40 8.0 water 10.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking period before testing see below 10.0 emulsion (target) 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing Aluminum		Cohes.Abrasion w/whe	els			11#5	
aggregate 1350.0 agg Temperature, F 77 80.6 F 0.5 cement / lime 6.8 cement cement Humidity, % 50 40 8.0 water 10.0 Aluminum sulfate 0.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking period before testing see below 10.0 emulsion (target) 135.0 emulsion cemulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	aggregate 1350.0 agg Temperature, F 77 80.6 F 0.5 cement / lime 6.8 cement Lumidity, % F Aumidity, %		weights,g		emperature, °C	25	27 ℃	
6.8 cement 108.0 water 0.0 Aluminum sulfate 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	6.8 cement Humidity, % 50 40 108.0 water Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing			<u> </u>	emperature, ℉		₩ 9.0	
108.0 water Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	Humidity, % 50 40 108.0 water Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing Compaction w/ roller immediately before testing	0.5 cement / lime						
108.0 water 0.0 Aluminum sulfate 135.0 emulsion Compaction w/ roller immediately before testing	108.0 water 0.0 Aluminum sulfate 135.0 emulsion Compaction w/ roller immediately before testing	Other:		I	lumidity, %	20	40	
0.0 Aluminum sulfate Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing	0.0 Aluminum sulfate Soaking period before testing see below 135.0 emulsion Compaction w/ roller immediately before testing	8.0 water		ļ				
135.0 emulsion Compaction w/roller immediately before testing	135.0 emulsion Compaction w/ roller immediately before testing	0.0 Aluminum sulfate	0.0 Aluminum		oaking period befo		ее регом	
Compaction w/ roller immediately before testing	Compaction w/ roller immediately before testing	10.0 emulsion (target)	135.0 emulsion					
		Other:		<u></u>	ompaction w/ rolle	er immediately before		
			,				•	

			_	_	_				_	_		_
⋖_	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	В	C=A-B
Original	Time	Clock	Temp	Humidity	Clock	Temp	Humidity	Period	time	of SOAK Final	Final	Loss
Wt, g	minutes	Time			Time			before test		water	Wt, g	Wt, g
1604.7	55	9:50	26.6	41	10:45	27	40	55 sec	65 sec	30	1359.7	245.0
1610.6	55	10:05	26.8	40	11:00	27	40	55 sec	65 sec	30	1371.1	239.5
1539.8	55	10:50	26.6	41	11:45	27	40	55 sec	65 sec	30	1297.9	241.9
					Temp of	Temp of test water:		30 ℃	_			

ժ∘ 98

Temp of test water:

Aggregate: Type 3 Emulsion: Englow MICRO LH Aggregate: Type 3 Emulsion: Englow Englow LH Source: TEXAS Source: ERGON ERGON ERGON Emulsion mid-range target: Pre-wet water mid-range target: Additive mid-range target: Additive: Mid-range target: Additive: Additive: Additive: Additive: Additive mid-range target: Additive: A	1) apply tack coat to disc and break emulsion 2) record weight of specimen after cure, before soaking 3) cover test specimen with water 4) abrade for time below	emulsion sure, before soaking
Emulsion: MICRO	2)record weight of specimen after of 3)cover test specimen with water 4)abrade for time below	cure, before soaking
Source: ERGON	3)cover test specimen with water 4)abrade for time below	
arget: 8.0 0.5 Additive: cement type 0.00 Additive: Aluminum s Additive: Aluminum s Additive: Additive	4)abrade for time below	
arget: 8.0 0.5 Additive: cement type 0.00 Additive: Aluminum s Additive:		
0.00 Additive: cement type 0.00 Additive: Aluminum s. Additive: Ad	5)rinse debris with 1000ml of water	
O.00 Additive: A	6)carefully pat dry with towel	
Additive: Additive: Cohes.Abrasion w/wheels weights,g 1350.0 agg 6.8 cement 108.0 water	7)record weight after test	
Additive: Cohes.Abrasion w/wheels weights.g		
Cohes.Abrasion w/wheels weights,g 1350.0 agg 6.8 cement 108.0 water		
Cohes.Abrasion w/wheels Cohes.Abrasion w/wheels weights,g aggregate 1350.0 agg Coment / lime 6.8 cement	ns:	
material weights,g aggregate 1350.0 agg 0.5 cement / lime 6.8 cement Other: 108.0 water	Control Eval#6	
aggregate 1350.0 agg 0.5 cement / lime 6.8 cement Other: 108.0 water	25 23	
6.8 cement	77 73.4 ∘F	
108.0 water		
108.0	90 20	
		į
0.0 Aluminum sulfate 0.0 Aluminum sulfate Soaking per	Soaking period before testing see below	
10.0 emulsion (target) 135.0 emulsion		
Other: Compaction	Compaction w/ roller immediately before testing	NONE

C=A-B	Loss	۸t, g	359.9	327.3	335.3
<u>Ö</u>		Wt, g	1214.9	1201.5	1228.8
Temp B	of SOAK Final	water	20	20	21
Abrasion	time		92 sec	65 sec	es sec
Soaking	Period	before test	60 55 sec	55 sec	55 sec
Final	Humidity		90	09	09
Final	Temp		23	23	23
End	Clock	Time	11:15	11:30	11:45
Initial	Humidity		09	09	09
Initial	Temp		22.6	22.9	23.1
Start	Clock	Time	10:10	10:25	10:40
Cure	Time	minutes	65	65	65
٧	Original	Wt, g	1574.8	1528.8	1564.1

Temp of test water:

CEL#: 10-17749	LAB#:	Date Tester	Mar-08	M5: Rugged	M5: Ruggedness Evaluation #7	
Project Name: Slurn	Slurry/Micro Mix Design	Tested By:	H	1)apply tack coa	1)apply tack coat to disc and break emulsion	
Aggregate: Type 3	Emulsion:	MICRO		2)record weight	2)record weight of specimen after cure, before soaking	oaking
Source: TEXAS	Source:	ERGON		3)cover test spe	3)cover test specimen with water	
Emulsion mid-range target:	10.0			4)abrade for time below	e below	
Pre-wet water mid-range target:	et: 8.0			5)rinse debris w	5)rinse debris with 1000ml of water	
Additive mid-range target:	0.5 Additive:	cement type 2	2	6)carefully pat dry with towel	ry with towel	
Additive mid-range target:	0.00 Additive:	Aluminum sulfate	lfate	7)record weight after test	after test	
Additive mid-range target:	Additive:					
Additive mid-range target:	Additive:					
			Curing Conditions:			
	Cohes.Abrasion w/wheels	els		Control	Eval#7	
% material	weights,g		Temperature, ℃	25	27 °C	
aggregate	1350.0 agg		Temperature, ℉	77	₩ 9.08	
0.5 cement / lime	6.8 cement					
Other:			Humidity, %	50	40	
8.0 water	108.0 water					
0.0 Aluminum sulfate	0.0 Aluminum sulfate		Soaking period before testing	e testing	see below	
10.0 emulsion (target)	135.0 emulsion					
Other:		O	Compaction w/ roller immediately before testing	immediately bef		NONE
		l Issa				

C=A-B	l Loss	g Wt, g	1386.5 197.0	1367.6 196.7	1400 E
Temp B	of SOAK Final	water Wt, g	20	20	00
Abrasion	time		55 sec	55 sec	75,000
Soaking	Period	before test	40 65 sec	65 sec	40 65 600
Final	Humidity		40	40	40
Final	Temp		27	27	27
End	Clock	Time	12:20	12:35	12.50
Initial	Humidity		40	40	40
Initial	Temp		27.4	27.0	27.1
Start	Clock	Time	11:15	11:30	11.45
Cure	Time	minutes	65	65	e L
٨	Original	Wt, g	1583.5	1564.3	16247

20 °C 68 °F

Temp of test water:

141

CEL#:	10-17749		LAB#:		Date Tester	. Mar-08		M5: Rugo	edness E	M5: Ruggedness Evaluation #8	#8	
Project Name:	me:	Slurry/Micr	Slurry/Micro Mix Design		Tested By: LH	크		1)apply tack	coat to disc	1)apply tack coat to disc and break emulsion	mulsion	
Aggregate: Type	Type 3			Emulsion:	MICRO			2)record we	ight of speci	2)record weight of specimen after cure, before soaking	re, before s	aking
Source:	TEXAS			Source:	ERGON			3)cover test specimen with water	specimen w	ith water		
Emulsion n	Emulsion mid-range target:	yet:	10.0					4)abrade for time below	time below			
Pre-wet wa	Pre-wet water mid-range target:	e target:	8.0					5)rinse debris with 1000ml of water	is with 1000	ml of water		
Additive mi	Additive mid-range target:	;;	0.5	0.5 Additive:	cement type 2	9.2		6)carefully pat dry with towel	at dry with t	owel		
Additive mi	Additive mid-range target:	;;	0.00	0.00 Additive:	Aluminum sulfate	ulfate		7)record weight after test	ight after tes	+-		
Additive mi	Additive mid-range target:	;;		Additive:								
Additive mi	Additive mid-range target:	;;		Additive:								
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sl			Control	Eval#8			
%	material		weights,g			Temperature,	re, °C	25	23	ပွ		
-	aggregate		1350.0	agg		Temperature, ℉	re, ℉	77	73.4	ĥ		
0.5	0.5 cement / lime	ē	6.8	cement								
	Other:					Humidity, %	%	20	40			
8.0	8.0 water		108.0	water								
0.0	0.0 Aluminum sulfate	ulfate	0.0	0.0 Aluminum sulfate	ulfate	Soaking pe	Soaking period before testing	testing	see t	see below		
10.0	10.0 emulsion (target)	rrget)	135.0	emulsion								
	Other:					Compactio	Compaction w/ roller immediately before testing	mm edia tely	before test	ing	NONE	NE
_∢	Cure	Start	Initial	Initial	End	Final	Final	Soaking	Abrasion	Temp	В	C=A-B
Original	Time	Clock	Temp	Humidity	Clock	Temp	Humidity	Period	time	of SOAK	Final	Loss
Wt, g	minutes	Time			Time			before test		water	Wt, g	Wt, g
1601.1	55	8:10	23.0	40	9:05	23	40	55 sec	55 sec	20	1330	271.1
1604.2	55	8:30	22.7	41	9:25	23	40	55 sec	55 sec	20	1289.8	314.4
1609.6	55	8:45	22.6	40	9:40	23	40	55 sec	55 sec	20	1344.6	265.0

20 ℃ 68 °F

Temp of test water:

2.CAT-Coh	esion Abra	asion Te	st: Fren	ch WTAT, s	short-term :	Mix 5					
Parameter ³	1. Cure Tir	2. Cure	e Temp.	3. Humidi	t 4. Test Tin	5. Test Te	6. Test D	uration			
Test No. 1	5	F	2°C	60	-5	30	-5	original	final	loss	final loss
	65 min	81.4	27.4	60	55 sec	30	55	1632.7	1391.2	241.5	242
	65 min	80.2	26.8	59	55 sec	30	55	1633.6	1368.1	265.5	266
	65 min	80.4	26.9	59	55 sec	30	55	1634.9	1361.6	273.3	273
Test No. 2	-5	F	2℃	60	5	20	5	original	final	loss	final loss
	55	80.8	27.1	60	65	20	65	1572.8	1397.0	175.8	176
	55	79.8	26.6	60	65	20	65	1613.1	1375.2	237.9	238
	55	80.2	26.8	60	65	20	65	1596.5	1340.9	255.6	256
Test No. 3	-5	F	-2℃	60	5	30	-5	original	final	loss	final loss
	55	72.9	22.7	59	65	30	55	1600.8	1251.3	349.5	350
	55	72.8	22.7	60	65	30	55	1619.9	1304.1	315.8	316
	55	73.5	23.1	59	65	30	55	1580.8	1268.8	312.0	312
Test No. 4	5	F	-2℃	40	5	30	5	original	final	loss	final loss
	65	73.2	22.9	40	65	30	65	1633.2	1259.2	374.0	374
	65	73.4	23.0	40	65	30	65	1632.3	1277.8	354.5	355
	65	73.7	23.2	40	64	30	65	1635.1	1250.0	385.1	385
Test No. 5	-5	F	2℃	40	-5	30	5	original	final	loss	final loss
	55	79.9	26.6	41	55	30	65	1604.7	1359.7	245.0	245
	55	80.3	26.8	40	55	30	65	1610.6	1371.1	239.5	240
	55	79.8	26.6	41	55	30	65	1539.8	1297.9	241.9	242
Test No. 6	5	F	-2℃	60	-5	20	5	original	final	loss	final loss
	65	72.6	22.6	60	55	20	65	1574.8	1214.9	359.9	360
	65	73.3	22.9	60	55	20	65	1528.8	1201.5	327.3	
	65	73.5	23.1	60	55	21	65	1564.1	1228.8	335.3	335
Test No. 7	5	F	2℃	40	5	20	-5	original	final	loss	final loss
	65	81.4	27.4	40	65	20	55	1583.5	1386.5	197.0	197
	65	80.6	27.0	40	65	20	55	1564.3	1367.6	196.7	197
	65	80.7	27.1	40	65	20	55	1624.7	1439.5	185.2	185
Test No. 8	-5	F	-2℃	40	-5	20	-5	original	final	loss	final loss
	55	73.4	23.0	40	55	20	55	1601.1	1330.0	271.1	
	55	72.8	22.7	41	55	20	55	1604.2	1289.8	314.4	314
	55	72.6	22.6	40	55	20	55	1609.6	1344.6	265.0	265

APPENDIX E LAB RESULTS FOR AGGREGATES AND EMULSIONS USED IN EXPERIMENTAL MIXES

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Source: George Reed, Table Mountain (A1)

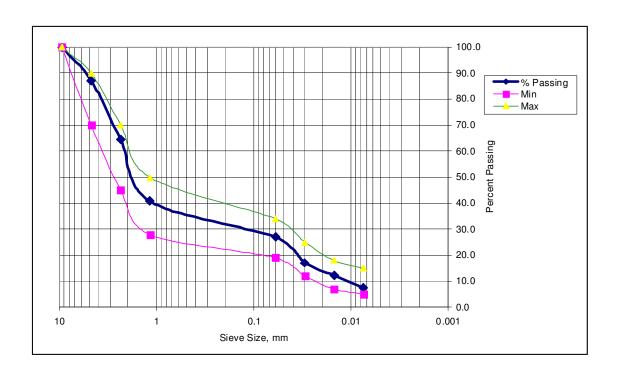
Aggregate: ISSA Type 3

Sampled ID: 1-01

SIEVE ANALYSIS per AASHTO T27

1021.7 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
130.8	#4	4.75	87.2	70	90
363.7	#8	2.36	64.4	45	70
604.8	#16	1.18	40.8	28	50
745.8	#30	0.06	27.0	19	34
847.0	#50	0.03	17.1	12	25
896.0	#100	0.015	12.3	7	18
946.1	#200	0.0075	7.4	5	15



Source: George Reed, Table Mountain (A1)

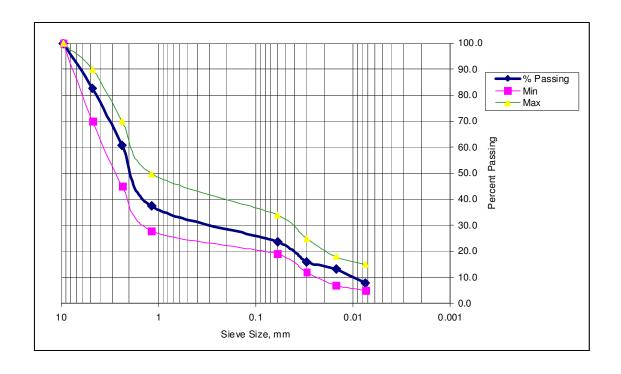
Aggregate: Sampled ID: ISSA Type 3

1-02

SIEVE ANALYSIS per AASHTO T27

525.8 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
90.9	#4	4.75	82.7	70	90
206.4	#8	2.36	60.7	45	70
329.1	#16	1.18	37.4	28	50
401.0	#30	0.06	23.7	19	34
441.2	#50	0.03	16.1	12	25
456.4	#100	0.015	13.2	7	18
484.5	#200	0.0075	7.9	5	15



Source: George Reed, Table Mountain (A1)

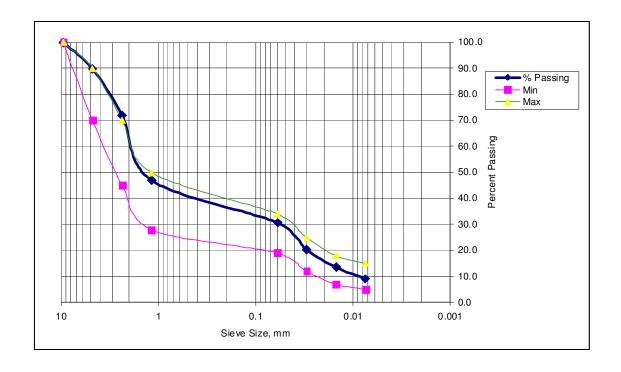
Aggregate: Sampled ID: ISSA Type 3

1-03

SIEVE ANALYSIS per AASHTO T27

640.8 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
65.3	#4	4.75	89.8	70	90
180.0	#8	2.36	71.9	45	70
339.7	#16	1.18	47.0	28	50
444.4	#30	0.06	30.6	19	34
510.9	#50	0.03	20.3	12	25
554.1	#100	0.015	13.5	7	18
582.6	#200	0.0075	9.1	5	15



Source: George Reed, Table Mountain (A1)

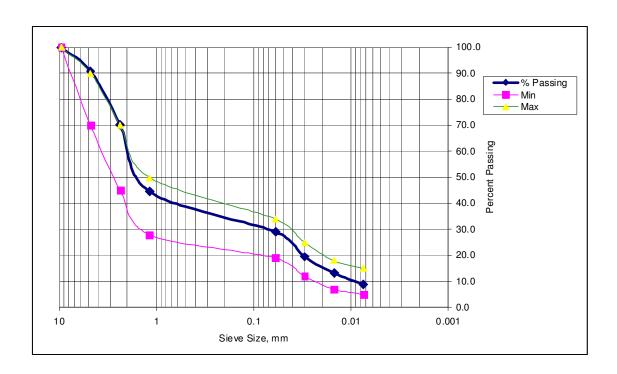
Aggregate: Sampled ID: ISSA Type 3

1-04

SIEVE ANALYSIS per AASHTO T27

1004.5 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
92.4	#4	4.75	90.8	70	90
298.9	#8	2.36	70.2	45	70
556.7	#16	1.18	44.6	28	50
712.2	#30	0.06	29.1	19	34
808.7	#50	0.03	19.5	12	25
872.7	#100	0.015	13.1	7	18
914.6	#200	0.0075	8.9	5	15



Source: George Reed, Table Mountain (A1)

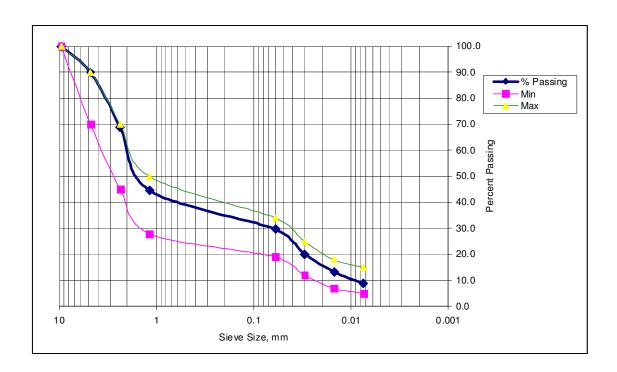
Aggregate: Sampled ID: ISSA Type 3

1-05

SIEVE ANALYSIS per AASHTO T27

1060.1 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
105.8	#4	4.75	90.0	70	90
329.9	#8	2.36	68.9	45	70
587.2	#16	1.18	44.6	28	50
745.5	#30	0.06	29.7	19	34
846.9	#50	0.03	20.1	12	25
918.6	#100	0.015	13.3	7	18
966.5	#200	0.0075	8.8	5	15



George Reed, Table Mountain (A1) Source:

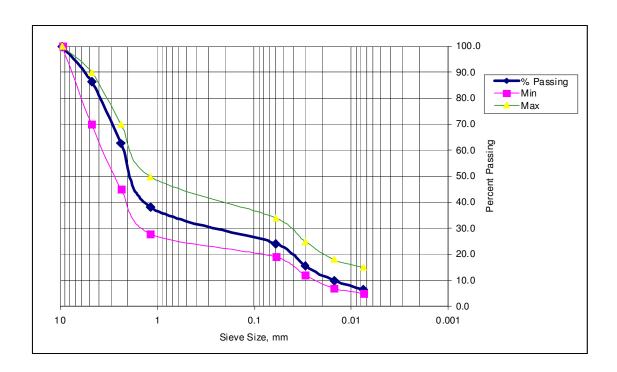
Aggregate: Sampled ID: ISSA Type 3

1-06

SIEVE ANALYSIS per AASHTO T27

1087.7 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
147.9	#4	4.75	86.4	70	90
405.7	#8	2.36	62.7	45	70
672.2	#16	1.18	38.2	28	50
824.5	#30	0.06	24.2	19	34
919.1	#50	0.03	15.5	12	25
980.0	#100	0.015	9.9	7	18
1018.1	#200	0.0075	6.4	5	15



Source: George Reed, Table Mountain (A1)

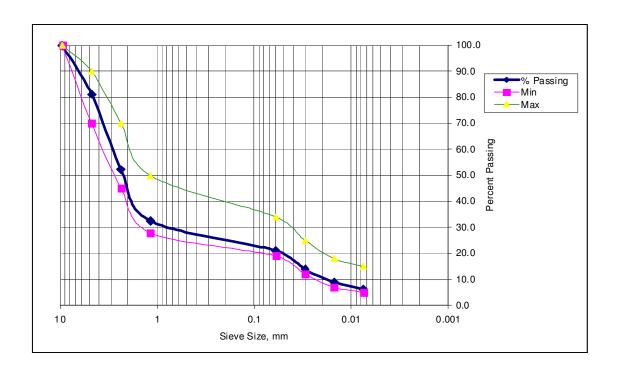
Aggregate: Sampled ID: ISSA Type 3

1-07

SIEVE ANALYSIS per AASHTO T27

1136.6 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
213.5	#4	4.75	81.2	70	90
542.5	#8	2.36	52.3	45	70
766.5	#16	1.18	32.6	28	50
897.5	#30	0.06	21.0	19	34
979.7	#50	0.03	13.8	12	25
1033.9	#100	0.015	9.0	7	18
1068.1	#200	0.0075	6.0	5	15



Source: George Reed, Table Mountain (A1)

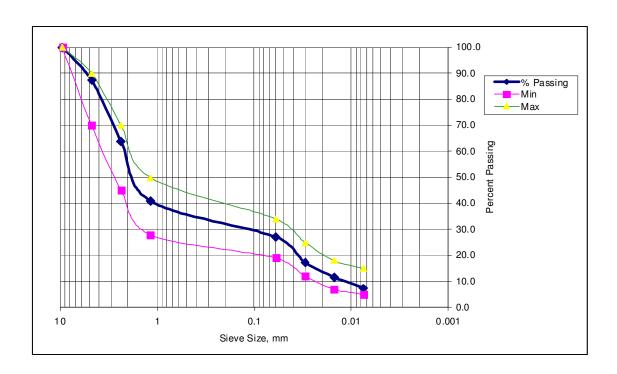
Aggregate: Sampled ID: ISSA Type 3

1-08

SIEVE ANALYSIS per AASHTO T27

1032.3 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
130.8	#4	4.75	87.3	70	90
372.9	#8	2.36	63.9	45	70
609.7	#16	1.18	40.9	28	50
752.5	#30	0.06	27.1	19	34
853.5	#50	0.03	17.3	12	25
912.0	#100	0.015	11.7	7	18
956.1	#200	0.0075	7.4	5	15



Source: George Reed, Table Mountain (A1)

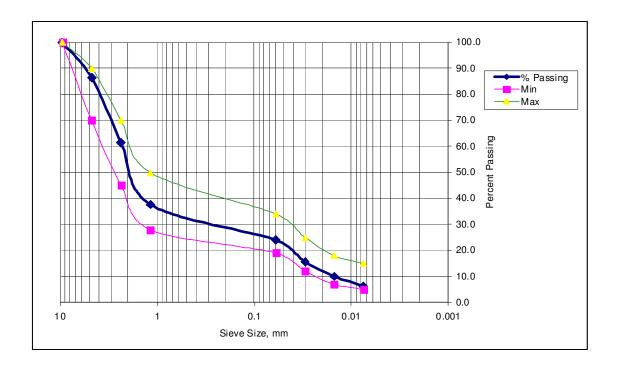
Aggregate: Sampled ID: ISSA Type 3

1-09

SIEVE ANALYSIS per AASHTO T27

1003.1 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
135.7	#4	4.75	86.5	70	90
387.5	#8	2.36	61.4	45	70
624.6	#16	1.18	37.7	28	50
763.0	#30	0.06	23.9	19	34
847.6	#50	0.03	15.5	12	25
902.5	#100	0.015	10.0	7	18
940.1	#200	0.0075	6.3	5	15



Source: George Reed, Table Mountain (A1)

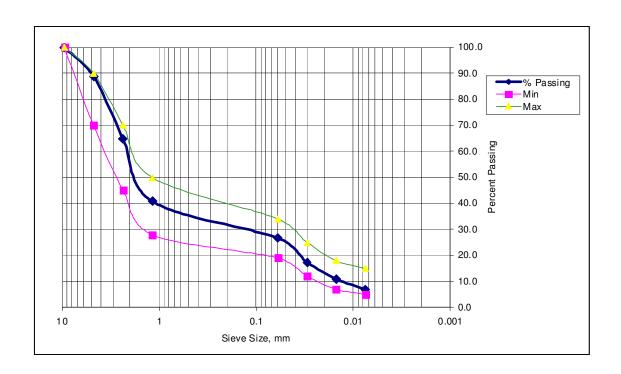
Aggregate: Sampled ID: ISSA Type 3

1-10

SIEVE ANALYSIS per AASHTO T27

523.8 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
58.6	#4	4.75	88.8	70	90
184.4	#8	2.36	64.8	45	70
310.1	#16	1.18	40.8	28	50
384.0	#30	0.06	26.7	19	34
433.1	#50	0.03	17.3	12	25
466.2	#100	0.015	11.0	7	18
487.7	#200	0.0075	6.9	5	15



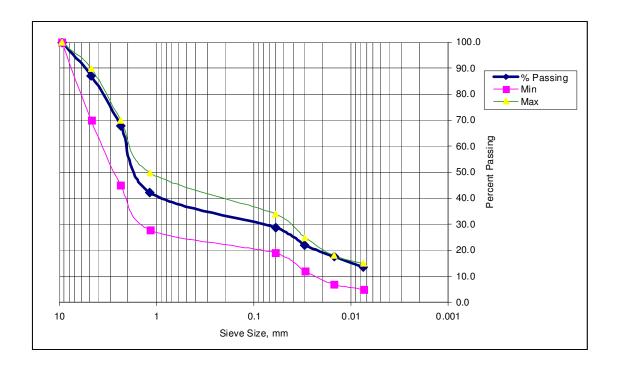
Source: Lopke (A2) Aggregate: Sampled ID: ISSA Type 3

2-01

SIEVE ANALYSIS per AASHTO T27

1012.9 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
129.7	#4	4.75	87.2	70	90
325.1	#8	2.36	67.9	45	70
584.4	#16	1.18	42.3	28	50
721.2	#30	0.06	28.8	19	34
790.1	#50	0.03	22.0	12	25
833.6	#100	0.015	17.7	7	18
874.1	#200	0.0075	13.7	5	15



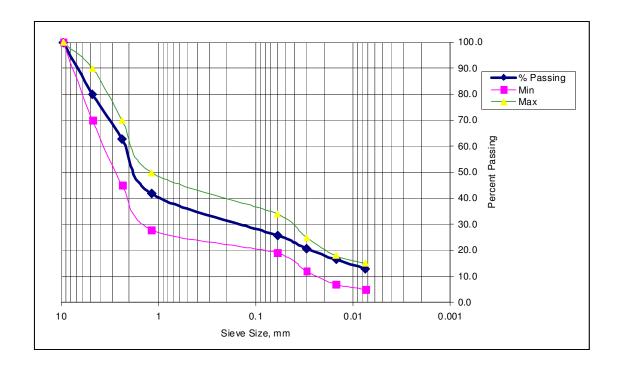
Source: Lopke (A2) Aggregate: Sampled ID: ISSA Type 3

2-02

SIEVE ANALYSIS per AASHTO T27

682 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
136.1	#4	4.75	80.0	70	90
253.6	#8	2.36	62.8	45	70
396.7	#16	1.18	41.8	28	50
506.0	#30	0.06	25.8	19	34
540.2	#50	0.03	20.8	12	25
569.5	#100	0.015	16.5	7	18
593.4	#200	0.0075	13.0	5	15



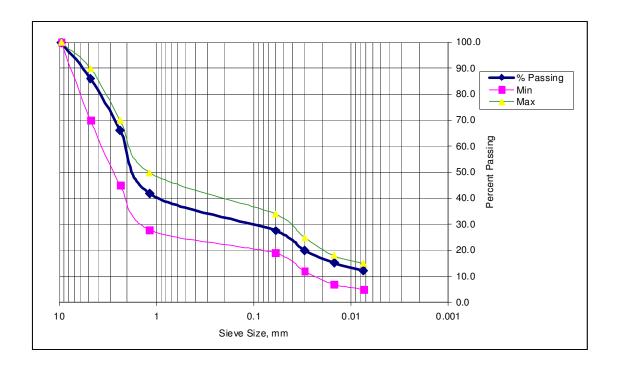
Source: Lopke (A2) Aggregate: Sampled ID: ISSA Type 3

2-03

SIEVE ANALYSIS per AASHTO T27

1000.3 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
139.0	#4	4.75	86.1	70	90
337.1	#8	2.36	66.3	45	70
581.2	#16	1.18	41.9	28	50
724.2	#30	0.06	27.6	19	34
800.2	#50	0.03	20.0	12	25
848.3	#100	0.015	15.2	7	18
878.3	#200	0.0075	12.2	5	15

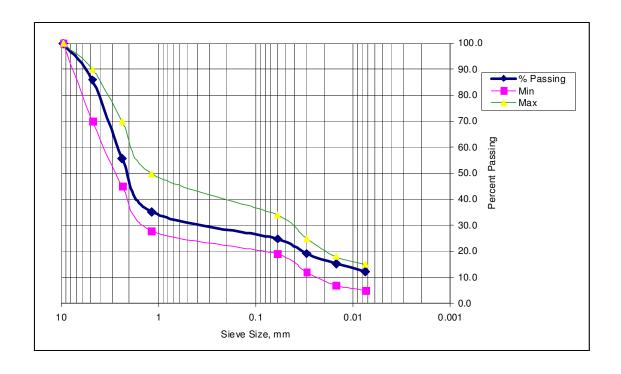


Source: Lopke (A2)
Aggregate: ISSA Type 3
Sampled ID: 2-04

SIEVE ANALYSIS per AASHTO T27

1036.4 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
145.2	#4	4.75	86.0	70	90
457.6	#8	2.36	55.8	45	70
671.1	#16	1.18	35.2	28	50
778.9	#30	0.06	24.8	19	34
838.0	#50	0.03	19.1	12	25
876.8	#100	0.015	15.4	7	18
908.6	#200	0.0075	12.3	5	15

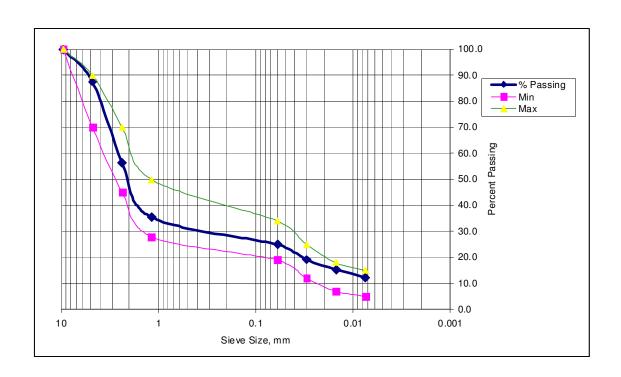


Source: Lopke (A2)
Aggregate: ISSA Type 3
Sampled ID: 2-05

SIEVE ANALYSIS per AASHTO T27

1024.3 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
126.6	#4	4.75	87.6	70	90
446.5	#8	2.36	56.4	45	70
661.1	#16	1.18	35.5	28	50
769.1	#30	0.06	24.9	19	34
828.2	#50	0.03	19.1	12	25
866.3	#100	0.015	15.4	7	18
898.2	#200	0.0075	12.3	5	15

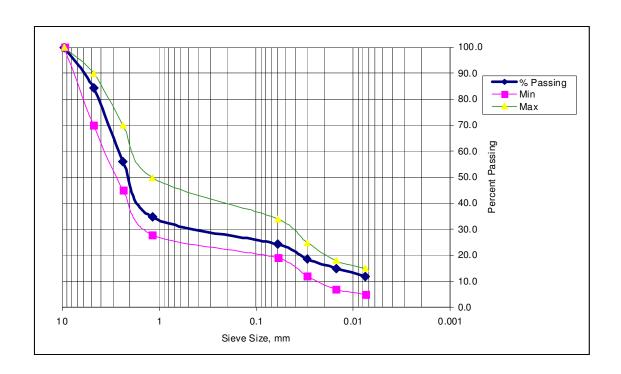


Source: Lopke (A2)
Aggregate: ISSA Type 3
Sampled ID: 2-06

SIEVE ANALYSIS per AASHTO T27

608.2 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
95.5	#4	4.75	84.3	70	90
267.2	#8	2.36	56.1	45	70
396.9	#16	1.18	34.7	28	50
460.3	#30	0.06	24.3	19	34
494.6	#50	0.03	18.7	12	25
516.7	#100	0.015	15.0	7	18
535.5	#200	0.0075	12.0	5	15



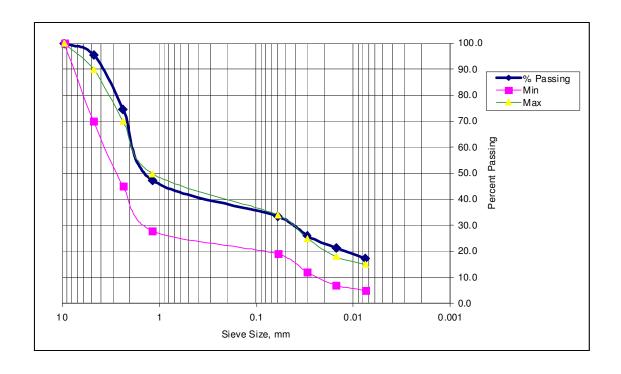
Source: Lopke (A2) Aggregate: Sampled ID: ISSA Type 3

2-07

SIEVE ANALYSIS per AASHTO T27

513.6 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
22.4	#4	4.75	95.6	70	90
129.4	#8	2.36	74.8	45	70
270.2	#16	1.18	47.4	28	50
341.9	#30	0.06	33.4	19	34
380.4	#50	0.03	25.9	12	25
404.5	#100	0.015	21.2	7	18
425.2	#200	0.0075	17.2	5	15

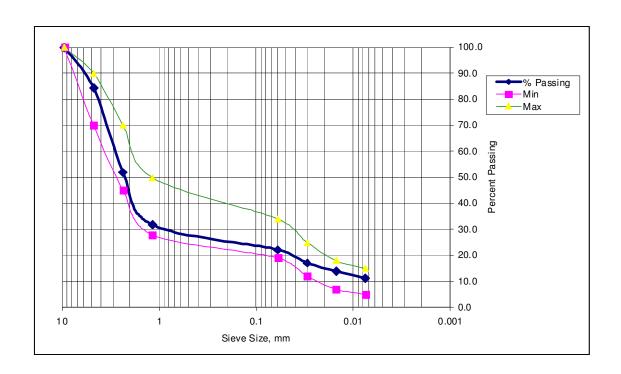


Source: Lopke (A2)
Aggregate: ISSA Type 3
Sampled ID: 2-08

SIEVE ANALYSIS per AASHTO T27

643.3 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
99.8	#4	4.75	84.5	70	90
309.5	#8	2.36	51.9	45	70
438.5	#16	1.18	31.8	28	50
500.6	#30	0.06	22.2	19	34
533.3	#50	0.03	17.1	12	25
553.7	#100	0.015	13.9	7	18
571.2	#200	0.0075	11.2	5	15

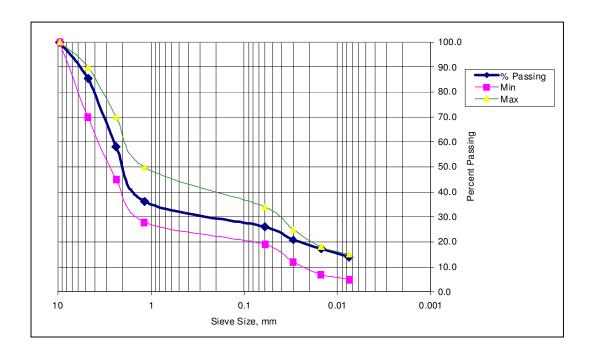


Source: Lopke (A2)
Aggregate: ISSA Type 3
Sampled ID: 2-09

SIEVE ANALYSIS per AASHTO T27

522.9 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
76.7	#4	4.75	85.3	70	90
219.0	#8	2.36	58.1	45	70
333.3	#16	1.18	36.3	28	50
386.5	#30	0.06	26.1	19	34
413.9	#50	0.03	20.8	12	25
432.2	#100	0.015	17.3	7	18
449.7	#200	0.0075	14.0	5	15



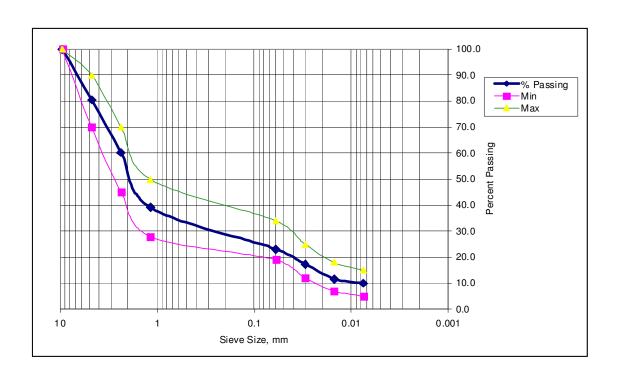
Source: Lopke (A2) Aggregate: ISSA Type 3

Sampled ID: 2-10

SIEVE ANALYSIS per AASHTO T27

1007.8 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Type 3	ISSA Specifications
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	100	100
195.8	#4	4.75	80.6	70	90
400.3	#8	2.36	60.3	45	70
612.7	#16	1.18	39.2	28	50
774.2	#30	0.06	23.2	19	34
832.8	#50	0.03	17.4	12	25
890.0	#100	0.015	11.7	7	18
906.5	#200	0.0075	10.1	5	15



Source: Texas (A3)

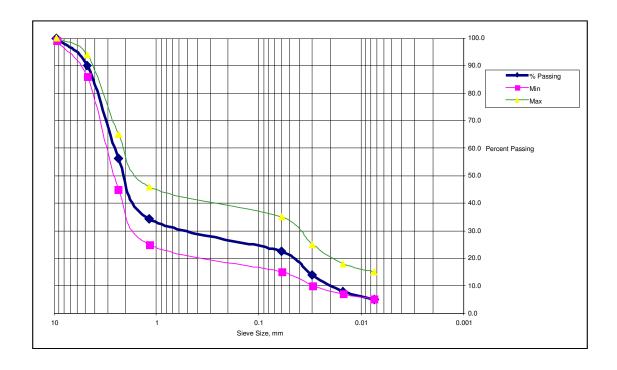
Aggregate: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

Sampled ID: 3-01

SIEVE ANALYSIS per AASHTO T27

1045.9 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	Min	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
104.6	#4	4.75	90.0	86	94
458.1	#8	2.36	56.2	45	65
687.2	#16	1.18	34.3	25	46
811.6	#30	0.06	22.4	15	35
901.6	#50	0.03	13.8	10	25
963.3	#100	0.015	7.9	7	18
992.6	#200	0.0075	5.1	5	15



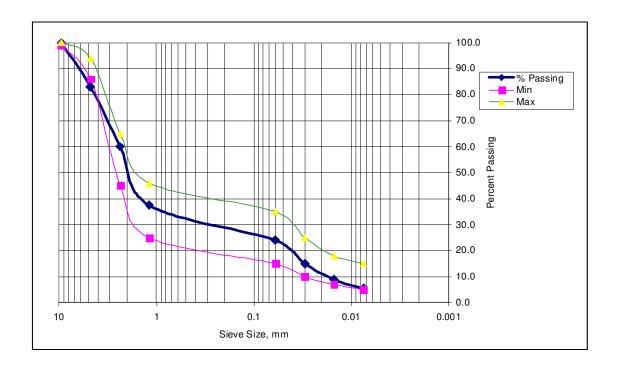
Texas (A3) Source:

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

523.5 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2, 7	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	Max
0.0	3/8"	9.5	100.0	99	100
88.8	#4	4.75	83.0	86	94
209.6	#8	2.36	60.0	45	65
327.6	#16	1.18	37.4	25	46
398.2	#30	0.06	23.9	15	35
444.6	#50	0.03	15.1	10	25
477.3	#100	0.015	8.8	7	18
494.9	#200	0.0075	5.5	5	15



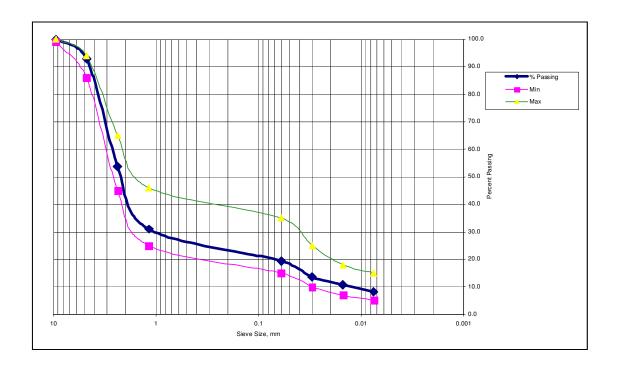
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

500 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
35.7	#4	4.75	92.9	86	94
231.2	#8	2.36	53.8	45	65
345.3	#16	1.18	30.9	25	46
402.9	#30	0.06	19.4	15	35
432.6	#50	0.03	13.5	10	25
446.7	#100	0.015	10.7	7	18
458.9	#200	0.0075	8.2	5	15



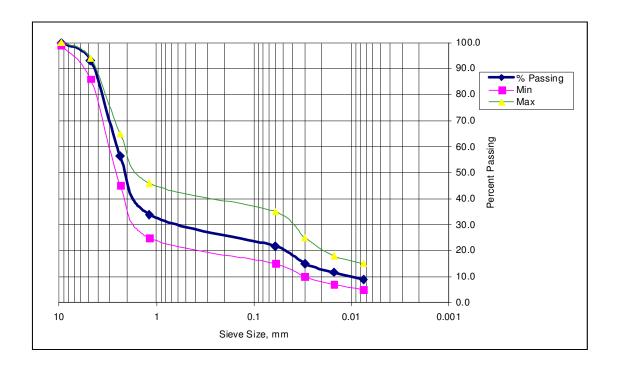
Texas (A3) Source:

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

500 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2, 1	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
34.0	#4	4.75	93.2	86	94
218.4	#8	2.36	56.3	45	65
330.4	#16	1.18	33.9	25	46
391.4	#30	0.06	21.7	15	35
425.1	#50	0.03	15.0	10	25
441.3	#100	0.015	11.7	7	18
454.8	#200	0.0075	9.0	5	15
218.4 330.4 391.4 425.1 441.3	#8 #16 #30 #50 #100	2.36 1.18 0.06 0.03 0.015	56.3 33.9 21.7 15.0 11.7	45 25 15 10 7	65 46 35 25 18



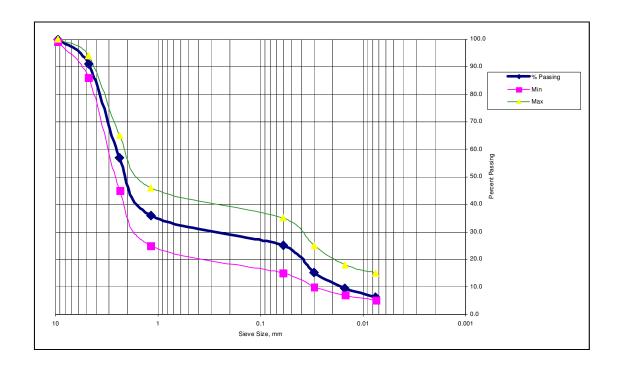
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

567.7 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2, 7	exas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
51.1	#4	4.75	91.0	86	94
245.2	#8	2.36	56.8	45	65
363.9	#16	1.18	35.9	25	46
425.8	#30	0.06	25.0	15	35
481.4	#50	0.03	15.2	10	25
513.8	#100	0.015	9.5	7	18
531.9	#200	0.0075	6.3	5	15



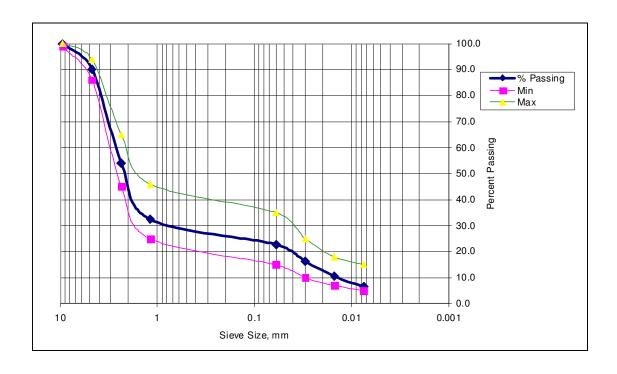
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

500 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
49.0	#4	4.75	90.2	86	94
229.5	#8	2.36	54.1	45	65
338.0	#16	1.18	32.4	25	46
386.0	#30	0.06	22.8	15	35
418.5	#50	0.03	16.3	10	25
447.5	#100	0.015	10.5	7	18
467.5	#200	0.0075	6.5	5	15



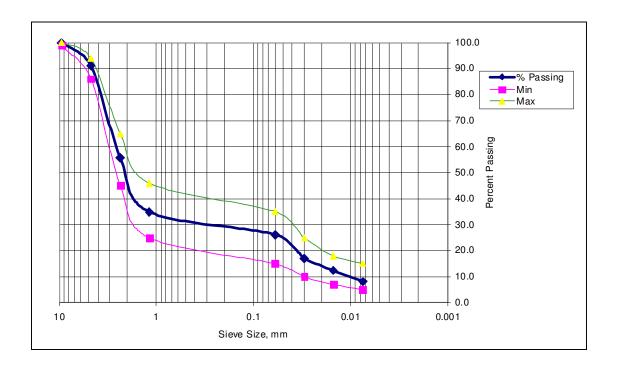
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

510.1 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2, 7	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
45.9	#4	4.75	91.0	86	94
226.5	#8	2.36	55.6	45	65
332.1	#16	1.18	34.9	25	46
376.5	#30	0.06	26.2	15	35
422.9	#50	0.03	17.1	10	25
446.8	#100	0.015	12.4	7	18
468.8	#200	0.0075	8.1	5	15



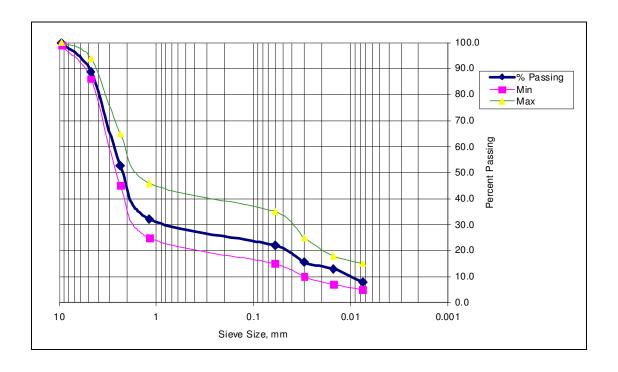
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

1021.1 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	100.0	99	100
113.3	#4	4.75	88.9	86	94
482.0	#8	2.36	52.8	45	65
692.3	#16	1.18	32.2	25	46
796.5	#30	0.06	22.0	15	35
862.9	#50	0.03	15.5	10	25
888.4	#100	0.015	13.0	7	18
941.5	#200	0.0075	7.8	5	15



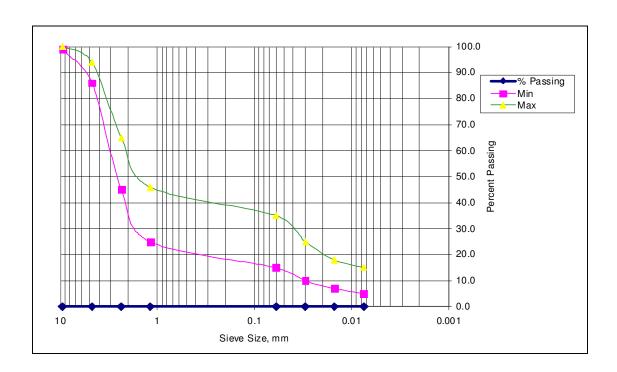
Source: Texas (A3)

Aggregate: Sampled ID: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

SIEVE ANALYSIS per AASHTO T27

ODry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	Max
0.0	3/8"	9.5	#DIV/0!	99	100
0.0	#4	4.75	#DIV/0!	86	94
0.0	#8	2.36	#DIV/0!	45	65
0.0	#16	1.18	#DIV/0!	25	46
0.0	#30	0.06	#DIV/0!	15	35
0.0	#50	0.03	#DIV/0!	10	25
0.0	#100	0.015	#DIV/0!	7	18
0.0	#200	0.0075	#DIV/0!	5	15



Source: Texas (A3)

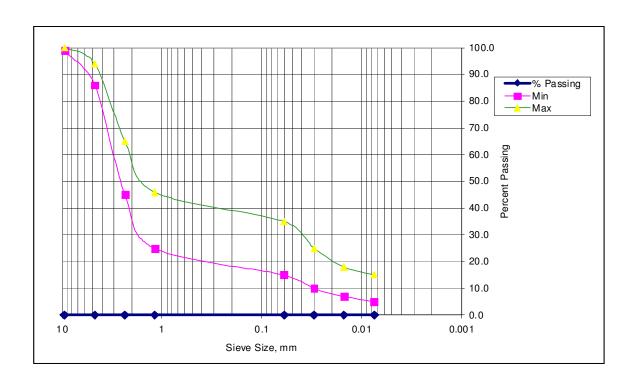
Aggregate: Grade 2 Texas (between Type 2 & Type 3 ISSA specs)

Sampled ID: 3-10

SIEVE ANALYSIS per AASHTO T27

0 Dry Weight of Sample before #200 Wash, g

Cumulative			Results	Grade 2,	Texas specs
Weight, g	Sieve Size	Sieve Size	% Passing	<u>Min</u>	<u>Max</u>
0.0	3/8"	9.5	#DIV/0!	99	100
0.0	#4	4.75	#DIV/0!	86	94
0.0	#8	2.36	#DIV/0!	45	65
0.0	#16	1.18	#DIV/0!	25	46
0.0	#30	0.06	#DIV/0!	15	35
0.0	#50	0.03	#DIV/0!	10	25
0.0	#100	0.015	#DIV/0!	7	18
0.0	#200	0.0075	#DIV/0!	5	15



SODIUM SULFATE SOUNDNESS FOR AGGREGATES A1, A2, AND A3

		Š	odium Sulfa	te Soundr	less per AA	SHTO for	Fine Ag	Sodium Sulfate Soundness per AASHTO for Fine Aggregate Samples	les		
CEL Number: 10-17749 Aggregate: A1 (Table Mountain)	10-17749 A1 (Table Mour	7749 Mountain)						Solution: Solution:	Sodium New	ium w	
Initial Bulk	Test Samp	Initial Bulk Test Sample Size, g:_	1021.7							% Passing	Weighted
FINE FRACTION	<u>~</u>							To make	Weight of	designated	Loss
Sieve	Ind'I Wt	Cum Wt	Cum %	Cum %	Ind'I%	70040	0)	grading equal	Fraction before test or		for Fine
	0.0	0.0	0.0	100.0	0.0	5		0.0	Deloie (est, 9		0.0
3/8"	0.0	0.0	0.0	100.0	0.0	0.0		0.0		0	0.0
#4	130.8	130.8	12.8	87.2	12.8	12.8		13.8	300.0	6.2	6.0
8#	232.9	363.7	35.6	64.4	23	22.8		24.6	100.0	4.9	1.2
#16	241.1	604.8	59.2	40.8	24	23.6		25.5	100.0	5.2	1.3
#30	141.0	745.8	73.0	27.0	4	13.8		14.9	100.1	4.3	9.0
#20	101.2	847.0	82.9	17.1	10	6.6		10.7	100.0	4.5	0.5
#100	49.0	0.968	87.7	12.3	2	4.8		5.2		0	0.0
#200	50.1	946.1	92.6	7.4	5	4.9	ı	5.3		0	0.0
pan+wash	75.6		0.0			7.4	snm	100.0		=mns	5
Check:	1021.7				93	100.0				(TOTAL final result reported to nearest whole number)	sult reported to le number)

SODIUM SULFATE SOUNDNESS FOR AGGREGATES A1, A2, AND A3

		Š	odium Sulfa	te Soundn	less per AA	SHTO for	Fine Ag	Sodium Sulfate Soundness per AASHTO for Fine Aggregate Samples	seles		
CEL Number: Aggregate:	10-17749 A2 (Lopke)	749 ppke)						Solution: Solution:	Sod	Sodium Used	
Initial Bulk	Initial Bulk Test Sample Size, g: 1012.9	e Size, g:	1012.9					-	: :	% Passing	Weighted
FRACTIC	<u>.</u>	;	,		:			lo make 	Weight of	designated	Loss
Sieve I Size F	Ind'I Wt Retained	Cum Wt Retained	Cum % Retained	Cum % Passing	Ind'1% Retained	check	0)	grading equal to 100%	Fraction before test, g	sieve after test	for Fine Fraction
	0.0	0.0	0.0	100.0	0.0			0.0			0.0
3/8"	0.0	0.0	0.0	100.0	0.0	0.0		0.0		0	0.0
#4	129.7	129.7	12.8	87.2	12.8	12.8		14.8	298.6	13.7	2.0
8#	195.4	325.1	32.1	6.79	19	19.3		22.4	100.0	9.5	2.1
#16	259.3	584.4	27.7	42.3	26	25.6		29.7	100.0	8.8	2.6
#30	136.8	721.2	71.2	28.8	4	13.5		15.7	100.0	8.8	4.
#20	68.9	790.1	78.0	22.0	7	6.8		7.9	100.0	8.0	9.0
#100	43.5	833.6	82.3	17.7	4	4.3		2.0		0	0.0
#200	40.5	874.1	86.3	13.7	4	4.0	I	4.6		0	0.0
pan+wash	138.8		0.0			13.7	snm	100.0		=mns	6
Check:	1012.9				86	100.0				(TOTAL final result reporte nearest whole number)	TOTAL final result reported to nearest whole number)

SODIUM SULFATE SOUNDNESS FOR AGGREGATES A1, A2, AND A3

֡				less per AA	SHTO for	Fine Ag	Sodium Sulfate Soundness per AASH I O for Fine Aggregate Samples			
10-1 / / 49 A3 (Texas)							Solution: Solution:	Soo	Sodium	
ole S	ize, g:	nitial Bulk Test Sample Size, g: 1045.9							: : :	Weighted
							To make	Weight of	% Fassing designated	rercentage Loss
			Cum %	% I.pul		Б	grading equal	Fraction		for Fine
	рө	eq	Passing	Retained	check		to 100%	before test, g	test	Fraction
	0.0	0.0	100.0	0.0			0.0			0.0
0.0	0.0	0.0	100.0	0.0	0.0		0.0		0	0.0
104.6 10	104.6	10.0	0.06	10.0	10.0		10.5	300.1	2.6	0.3
	58.1	43.8	56.2	34	33.8		35.6	100.0	3.7	1.3
229.1 68	687.2	65.7	34.3	22	21.9		23.1	100.0	5.6	1.3
124.4 81	11.6	77.6	22.4	12	11.9		12.5	100.0	5.2	0.7
90.0	01.6	86.2	13.8	6	9.8		9.1	100.0	3.1	0.3
61.7 96	963.3	92.1	6.7	9	5.9		6.2		0	0.0
29.3 99	992.6	94.9	5.1	3	2.8	ı	3.0		0	0.0
53.3		0.0			5.1	sum	100.0		=mns	4
045.9				92	100.0				(TOTAL final result reported to nearest whole number)	sult reported to

DURABILITY OF FINE AGGREGATE FOR A3

Durak	oility of Fine Ag	ggregate per Cal 229	9
CEL Number: 10-1	7749	Aggregate ID:	A3 (Texas)
Sample: 3-	01	Trial:	1
Soaking Time, Start:	10	minutes	
Soaking Time, End:	0	10 +/- 1 min	
Sedimentation, Start:	20		
Sedimentation, End:	0	at 20 min	
Clay Reading, C:	5.2		
Sand Reading, S:	3.9		
Df (S/C)*100:	75.0		
Df to Round Up:	75		
Durability to Report:	75		

ABRASION LOSS BY AASHTO T-96 FOR AGGREGATES A1, A2, AND A3

Abrasion Loss b	y LA Rattler	Machine per AASHTO T-96
CEL Number: 10-17	749	Aggregate ID: A1 (Table Mountain)
_		
Sieve Size Used:	#4 x #	#8
Grading Used:	D	
Grading Wt to Use, g:	5000 +/-	- 10
Initial Sample Wt, g:	5000.	.5
Number of Spheres Used:	6	
Mass of Charges to Use, g:	2500 +/-	- 15
Mass of Charges Used, g:	2508.	.5
Wt of Sample After 500 Revs, g:	4103.	.8 Retained on #12
Percent Loss After 500 Revs:	18	
_		

Abrasion Loss b	y LA Rattler Mach	nine per AASHTO T-96
CEL Number: 10-17	749	Aggregate ID: A2 (Lopke)
Sieve Size Used:	#4 x #8	
Grading Used:	D	
Grading Wt to Use, g:	5000 +/- 10	
Initial Sample Wt, g:	5000.2	
Number of Spheres Used:	6	
Mass of Charges to Use, g:	2500 +/- 15	
Mass of Charges Used, g:	2512.2	
Wt of Sample After 500 Revs, g:	3845.9	Retained on #12
Percent Loss After 500 Revs:	23	
_		

Abrasion Loss b	y LA Rattler Mac	hine per AASHTO T-96
CEL Number: 10-17	749	Aggregate ID: A3 (Texas)
Ciava Ciaa Haadi	#4 v #0	
Sieve Size Used:	#4 x #8	
Grading Used:	D	
Grading Wt to Use, g:	5000 +/- 10	
Initial Sample Wt, g:	5001.8	
Number of Spheres Used:	6	
Mass of Charges to Use, g:	2500 +/- 15	
Mass of Charges Used, g:	2508.5	
Wt of Sample After 500 Revs, g:	3732.3	Retained on #12
Percent Loss After 500 Revs:	25	

SAND EQUIVALENT FOR AGGREGATES A1, AND A2

Sand Equivalent Valu	e of Soils a	nd Fine Agg	regate per	AASHTO T176
	L Number: Aggregate:	10-1 A1 (Table	7749 Mountain)	- -
Sample# 1-01 Soaking time: Start Soaking time: End Sedimentation: Start Sedimentation: End Clay reading, C Sand reading, S SE (S/C)*100 SE to Round Up Average SE to Report	Trial 1 0 10 1147 3147 4.9 4 81.6 82 81	Trial 2 3 13 1435 3435 4.8 3.9 81.3	Trial 3 6 16 1649 3649 4.9 3.9 79.6	minutes 10 +/- 1 min @ 20 min
Sample# 1-09 Soaking time: Start Soaking time: End Sedimentation: Start Sedimentation: End Clay reading, C Sand reading, S SE (S/C)*100 SE to Round Up Average SE to Report	Trial 1 0 10 1158 3158 4.9 4.1 83.7 84 82	Trial 2 3 13 1428 3428 4.7 3.8 80.9 81	Trial 3 6 16 1652 3652 5.1 4.1 80.4 81	minutes 10 +/- 1 min @ 20 min

SAND EQUIVALENT FOR AGGREGATES A1, AND A2

Sand Equivalent Valu	e of Soils a	nd Fine Ago	gregate per	AASHTO T176
CF	L Number:	10-1	7749	
	Aggregate:			-
	· iggi ogalo	712 (2	οριτο,	_
Sample# 2-01	Trial 1	Trial 2	Trial 3	
Soaking time: start	0	3	6	minutes
Soaking time: end	10	13	16	10 +/- 1 min
Sedimentation: start	1210	1421	1630	7
Sedimentation: end	3210	3421	3630	@ 20 min
Clay reading, C	6.8	6.7	6.7	1
Sand reading, S	4.3	4.2	4.1	
SE (S/C)*100	63.2	62.7	61.2	1
SE to round up	64	63	62	
Average SE to report	63			•
'				
Sample# 2-02	Trial 1	Trial 2	Trial 3	
Soaking time: start	0	3	6	minutes
Soaking time: end	10	13	16	10 +/- 1 min
Sedimentation: start	1201	1423	1638	1
Sedimentation: end	3201	3423	3652	@ 20 min
Clay reading, C	6.9	6.8	7.0	
Sand reading, S	4.4	4.5	4.5	1
SE (S/C)*100	63.8	66.2	64.3	1
SE to round up	64	67	65	
Average SE to report	66			_
Sample# 2-09	Trial 1	Trial 2	Trial 3	
Soaking time: start	0	3	6	minutes
Soaking time: end	10	13	16	10 +/- 1 min
Sedimentation: start	1226	1453	1654	7
Sedimentation: end	3226	3453	3654	@ 20 min
Clay reading, C	6.8	6.9	7.1	1
Sand reading, S	4.3	4.4	4.5	1
SE (S/C)*100	63.2	63.8	63.4	1
SE to round up	64	64	64	1
Average SE to report	64			_
' '				

SAND EQUIVALENT FOR AGGREGATES A1, AND A2

Sand Equivalent Valu	e of Soils a	nd Fine Agg	regate per	AASHTO T176
	EL Number: Aggregate:		7749 Mountain)	- -
Sample# 1-01 Soaking time: Start Soaking time: End Sedimentation: Start Sedimentation: End Clay reading, C Sand reading, S SE (S/C)*100 SE to Round Up Average SE to Report	Trial 1 0 10 1215 3215 6.1 4.4 72.1 73 72	Trial 2 3 13 1422 3422 6.4 4.5 70.3	Trial 3 6 16 1630 3630 6.4 4.6 71.9	minutes 10 +/- 1 min @ 20 min
Sample# Soaking time: Start Soaking time: End Sedimentation: Start Sedimentation: End Clay reading, C Sand reading, S SE (S/C)*100 SE to Round Up Average SE to Report	Trial 1 0 10	Trial 2 3 13	Trial 3 6 16	minutes 10 +/- 1 min @ 20 min

ABRASION LOSS BY ASTM D6928 FOR AGGREGATES A1, A2, AND A3

CEL#	10-17749	
Aggregate:	TABLE MOUNTAIN	
Abrasion Loss by Mi	cro-Deval per ASTM D6928	
Sieve Size	Cumulative Wt of Sample, g	
3/8"	0.0	
1/4"	750.0	_
#4	1501.6	а
Steel ball Wt, g:	4999.8	,
Time Running, min:	95	_
Wt of sample after		
test, g:	1414.3	b
% of Loss:	5.8	

CEL# Aggregate:	10-17749 A2-Lopke	
0		
Sieve Size	Cumulative Wt of Sample, g	
3/8"	0.0	
1/4"	277.0	
#4	1500.6	а
Steel ball Wt, g:	4999.8	
Time Running, min:	95	
Wt of sample after		
test, g:	1227.5	b
% of Loss:	18.2	

CEL#	10-17749	
Aggregate:	A3-Texas	
0		
0: 0:	0 1 1: 141: 10 1	
Sieve Size	Cumulative Wt of Sample, g	
3/8"	0.0	
1/4"	180.3	
#4	1500.3	а
Steel ball Wt, g:	4999.8	
Time Running, min:	95	
Wt of sample after		
test, g:	1255	b
% of Loss:	16.4	

CEL# 10-17749 Source: Sem Materials Material: Ralumac		
CTM 331: Residue by Evaporation_ Tested By:Ih		T59: Residue by Distillation Tested By cg
tare identification 1 2 3		A'=Initial sample wt, g: 199.9 or 200.0 or 200.1 200
B: tare wt (beaker+rod), g 62.6 61.8 64.6	9	B'=Tare wt,g (still, lid, clamp, them's, gasket) 3460.9
emulsion weight, g 40.1 40 40.1	1 C=Average	start time: 10:00 end time: 11:18 total time: 1:18
A: final total dry weight, g 87.7 87.5 90.5	5 Residue,%	D'=Total final wt,g (tare & distilled sample) 3594.7
Res, % 62.8 64.3 64.8	8 63.9	E'=Final sample wt, g=(D'-B')
emulsion weight = 39.9g or 40.0g or 40.1g		C'=Residue, %= (E'/A')100 C'= 66.9
residue, % = 2.5[A-B] start time @ 118°C: 6:15	5	1. distillation time: 60 +/- 15 min
@30m, increase temp to 138°C: 6:45	5	
after 1.5h, stir and return to oven: 8:15	2	
complete after add'l 1.0h: 9:15	5	
T49: Penetration of Bituminous Mate	T53: Ring &	53: Ring & Ball Softening Point
Tested By: LH Test temp, °C: 25	Tested By:	Liquid Bath Used: Boiled Distilled Water
Time, s: 5		Left side Right Side
Cup#1 Load, g: 100		C: 57.5 °C: 58
Trial #1: 49		
Trial #2: 50		Softening Point to Report, °C: 57.8
Trial #3: 50		
AVERAGE: 50	1. Heat sampl	1. Heat sample no more than 110 °C above expected softening point within 2 hr max.
Report to the nearest whole unit the average of 3 penetrations	2. Pour sampl	Pour sample into heated rings. Total time from this point not to exceed 240 min.
whose values do not differ by more than the following:	3. Cool, at am	Cool, at ambient, for 30min. Trim excess wheated spatula.
Pen range: 0-49 50-149	4. Assemble a	4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; retum to refrig
Max difference b $\frac{2}{}$	or ice bath for 15 min	15 min
highest & lowest penetration result	5. Apply heat	5. Apply heat at 5 ${ m C/min}$. After first 3min, max. variation is +/-0.5 ${ m C}$
	6. If the differe	6. If the difference between the two temperatures exceeds 1 $^{\circ}$ C (2 $^{\circ}$ F), repeat the test.
	7. When using	7. When using a 15C or 15F thermometer (low temprange), then report to nearest 0.2° C $(0.5^{\circ}$ F)

		Ī				
Source: Sem Materials		I				
Material: Ralumac	verificatio	verification testing				
CTM 331: Residue by Evaporation	u			T59: Residue by Distillation		
Tested By:Ih				Tested By cg		
tare identification	2	3		A'=Initial sample wt, g: 199.9 or 200.0 or 200.1	not tested	
B:tare wt (beaker+rod), g	65.5	65 64.2		B'=Tare wt,g (still, lid, clamp, therm's, gasket)	0	
emulsion weight, g	40 4	40 40.1	C=Average	start time: end time: total time:		
A: final total dry weight, g	90.3	4 89.8	Residue,%	D'=Total final wt,g (tare & distilled sample)	0	
Res, % 6	62.0 63.5	5 64.0	63.2	E'=Final sample wt, g=(D'-B')	0.0	
emulsion weight = 39.9g or 40	40.0g or 40.1g	lg		C'=Residue, %= (E'/A')100 C'=	#VALUE!	
residue, $\% = 2.5[A-B]$ start t	start time @ 118°C:	7:15		1. distillation time: 60 +/- 15 min		
@30m, increase temp to 138°C:	emp to 138℃	7:45				
after 1.5h, stir and return to oven:	eturn to over	3:15				
complete a	complete after add'l 1.0h:	10:15				
T49: Penetration of Bituminous Mate	late		T53: Ring & I	T53: Ring & Ball Softening Point		
Tested By: LH	Test tem	Test temp, °C: 25	Tested By:	Liquid Bath Used:	Boiled Distilled Water	Water
	Time, s:	5		Left side Right Side	١٥	
Cup#1	Load, g: 100	100		°C: 57.5 °C: 58.1		
Trial #1: 52						
Trial #2: 51				Softening Point to Report, °C:	57.8	
Trial #3: 49						
AVERAGE: 51			1. Heat sample	1. Heat sample no more than 110 ${\mathcal C}$ above expected softening point within 2 hr max.	in 2 hr max.	
Report to the nearest whole unit the average of 3 penetrations	average of 3 p	enetrations	2. Pour sample	Pour sample into heated rings. Total time from this point not to exceed 240 min.	1 240 min.	
whose values do not differ by more than the following:	han the followi	ing:	3. Cool, at am	3. Cool, at ambient, for 30min. Trim excess wheated spatula.		
Pen range: <u>0-49</u> <u>50-149</u>	<u>61</u>		4. Assemble a	4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; return to refrig	pth; retum to refriç	_
Max difference b 2 4			or ice bath for 15 min	15 min		
highest & lowest penetration result			5. Apply heat	5. Apply heat at 5°C/min. After first 3min, max. variation is ± -0.5 °C		
			6. If the differe	6. If the difference between the two temperatures exceeds 1 $^{\circ}$ C (2 $^{\circ}$ F), repeat the test.	eat the test.	
			7. When using	7. When using a 15C or 15F thermometer (low temp range), then report to nearest $0.2^{\circ}\mathrm{C}$ $(0.5^{\circ}\mathrm{F})$	o nearest 0.2℃ (0.	5 °F)
						,

CEL#

Boiled Distilled Water 7. When using a 15C or 15F thermometer (low temp range), then report to nearest 0.2°C (0.5°F) 4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; return to refrig 0.0 #VALUE! not tested 61.3 1. Heat sample no more than 110 °C above expected softening point within 2 hr max. 6. If the difference between the two temperatures exceeds $1^{\circ}C(2^{\circ}F)$, repeat the test. 2. Pour sample into heated rings. Total time from this point not to exceed 240 min. 61.5 Right Side Softening Point to Report, °C: S total time: Liquid Bath Used: A'=Initial sample wt, g: 199.9 or 200.0 or 200.1 5. Apply heat at 5 °C/min. After first 3min, max. variation is +/-0.5 °C B'=Tare wt,g (still, lid, clamp, therm's, gasket) ပ္ပဲ 3. Cool, at ambient, for 30min. Trim excess wheated spatula. D'=Total final wt,g (tare & distilled sample) distillation time: 60 +/- 15 min end time: T59: Residue by Distillation E'=Final sample wt, g=(D'-B') C'=Residue, %= (E'/A')100 eft side 153: Ring & Ball Softening Point ested By cg start time: <u>ن</u> or ice bath for 15 min Fested By: LH C=Average Residue,% 64.2 40 90.8 6:15 6:45 8:15 9:15 7.49 65.3 Report to the nearest whole unit the average of 3 penetrations verification testing က Test temp, °C: 25 Load, g: 100 40.1g whose values do not differ by more than the following: Time, s: 5 89.2 63.0 8 8 start time @ 118°C: @30m, increase temp to 138°C: after 1.5h, stir and return to oven: complete after add'l 1.0h: N mulsion weight = 39.9g or 40.0g or 90.6 64.3 64.9 40 49: Penetration of Bituminous Mate 50-149 **STM 331: Residue by Evaporation** ighest & lowest penetration result 48 47 A: final total dry weight, g Cup#1 3: tare wt (beaker+rod), 0-49 esidue, % = 2.5[A-B] 47 N Ralumac emulsion weight, g are identification Max difference b Trial #3: AVERAGE: Trial #2: Fested By: LH Trial #1: ested By: Ih Res. % en range: Material:

Sem Materials

CEL# Source:

Material: PMCQS-1h		
CTM 331: Residue by Evaporation		T59: Residue by Distillation
Tested By: lh		Tested By cg
tare identification 1 2 3		A'=Initial sample wt, g: 199.9 or 200.0 or 200.1
B:tare wt (beaker+rod), g 65.4 66.1 66.2	2.2	B'=Tare wt,g (still, lid, clamp, them's, gasket) 3461.4
emulsion weight, g 40 40 40.1).1 C=Average	start time: 9:45 end time: 10:55 total time: 1:10
A: final total dry weight, g 89.9 90.4 90.	90.5 Residue,%	D'=Total final wt,g (tare & distilled sample) 3587.3
Res, % 60.8 60.8	6.09 8.0	E'=Final sample wt, $g=(D'-B')$
emulsion weight = $39.9g$ or $40.0g$ or $40.1g$		C'=Residue, %= (E'/A')100 C'= 62.9
residue, % = 2.5[A-B] start time @ 118°C: 5:30	30	1. distillation time: 60 +/- 15 min
@30m, increase temp to 138°C: 6:00	00	
after 1.5h, stir and return to oven: 7:30	30	
complete after add'l 1.0h: 8:30	30	
T49: Penetration of Bituminous Mate	T53: Ring &	53: Ring & Ball Softening Point
Tested By: LH Test temp, °C: 25	Tested By:	Liquid Bath Used: Boiled Distilled Water
Time, s: 5		Left side Right Side
Cup#1 Load, g: 100		°C: 55 °C: 55.1
Trial #1: 73		
Trial #2: 71		Softening Point to Report, °C: 55.1
Trial #3: 74		
AVERAGE: 73	1. Heat sampl	1. Heat sample no more than 110 $^\circ\! C$ above expected softening point within 2 hr max.
Report to the nearest whole unit the average of 3 penetrations	2. Pour sampl	2. Pour sample into heated rings. Total time from this point not to exceed 240 min.
whose values do not differ by more than the following:	3. Cool, at am	3. Cool, at ambient, for 30min. Trim excess w/heated spatula.
Pen range: <u>0-49</u> <u>50-149</u>	4. Assemble a	4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; return to refrig
Max difference b $\frac{2}{}$ $\frac{4}{}$	or ice bath for 15 min	15 min
highest & lowest penetration result	5. Apply heat	5. Apply heat at 5°C/min. After first 3min, max. variation is +/-0.5°C
	6. If the differe	6. If the difference between the two temperatures exceeds 1 $^{\circ}$ C (2 $^{\circ}$ C), repeat the test.
	7. When using	7. When using a 15C or 15F thermometer (low temp range), then report to nearest 0.2℃ (0.5 円)

Source: VSS Emultech

Boiled Distilled Water 7. When using a 15C or 15F thermometer (low temp range), then report to nearest 0.2°C (0.5°F) 4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; return to refrig 0.0 #VALUE! not tested 54.5 1. Heat sample no more than 110 °C above expected softening point within 2 hr max. 6. If the difference between the two temperatures exceeds 1 $^{\circ}$ C (2 $^{\circ}$ F), repeat the test. 2. Pour sample into heated rings. Total time from this point not to exceed 240 min. Right Side total time: U. Softening Point to Report, °C: Liquid Bath Used: A'=Initial sample wt, g: 199.9 or 200.0 or 200.1 5. Apply heat at 5 °C/min. After first 3min, max. variation is +/-0.5 °C B'=Tare wt,g (still, lid, clamp, therm's, gasket) 3. Cool, at ambient, for 30min. Trim excess w/heated spatula. ن D'=Total final wt,g (tare & distilled sample) 1. distillation time: 60 +/- 15 min end time: E'=Final sample wt, g=(D'-B') Fesidue by Distillation C'=Residue, % = (E'/A')10054.9 eftside T53: Ring & Ball Softening Point Fested By cg C=Average start time: ပ္ပဲ or ice bath for 15 min Tested By: LH Residue,% 60.2 40 89.3 65.3 6:00 6:30 8:00 9:00 60.0 Report to the nearest whole unit the average of 3 penetrations က Test temp, °C: 25 Load, g: 100 Time, s: 5 whose values do not differ by more than the following: 40.1g 64.7 88.8 60.3 start time @ 118°C: 8 @30m, increase temp to 138°C: after 1.5h, stir and return to oven: complete after add'l 1.0h: a or 40.0g or 88.4 60.3 64.3 749: Penetration of Bituminous Mate 40.1 STM 331: Residue by Evaporation 41 84 ighest & lowest penetration A: final total dry weight, g emulsion weight = 39.9g B: tare wt (beaker+rod), Cup#1 PMCQS-1h 0-49 82 S esidue, % = 2.5[A-B] emulsion weight, g are identification Max difference b **AVERAGE**: Trial #1: rrial #2: Fested By: LH Trial #3: Fested By: Ih Pen range: Res, %

VSS Emultech

CEL# Source: Material:

Material: Micro emulsion			
CTM 331: Residue by Evaporation		T59: Residue by Distillation	
Tested By Ih		Tested By.cg	
tare identification 1 2 3		A'=Initial sample wt, g: 199.9 or 200.0 or 200.1	
B:tare wt (beaker+rod), g 64.7 64.6 64	64.8	B'=Tare wt,g (still, lid, clamp, therm's, gasket) 3460.8	
emulsion weight, g 40 40	40 C=Average	start time: 10:10 end time: 11:30 total time: 1:20	
A: final total dry weight, g 90.1 89.8 89	89.7 Residue,%	D'=Total final wt,g (tare & distilled sample) 3590	
Res, % 63.5 63.0 62	62.3 62.9	E'=Final sample wt, g=(D'-B')	
emulsion weight = $39.9g$ or $40.0g$ or $40.1g$		C'=Residue, %= (E'/A')100	
residue, % = 2.5[A-B] start time @ 118°C: 5::	5:30	1. distillation time: 60 +/- 15 min	
@30m, increase temp to 138°C: 6:0	6:00		
	7:30		
complete after add'l 1.0h:	8:30		
T49: Penetration of Bituminous Mate	T53: Ring &	T53: Ring & Ball Softening Point	
Tested By LH Test temp, °C: 25	Tested By:	LH Liquid Bath Used: Boiled Distilled Water	ter
Time, s: 5		Left side Right Side	
Cup#1 Load, g: 100		°C: 58.5 °C: 58	
Trial #1: 64			
Trial #2: 65		Softening Point to Report, °C: 58.3	
Trial #3: 62			
AVERAGE: 64	1. Heat sampl	1. Heat sample no more than 110°C above expected softening point within 2 hr max.	
Report to the nearest whole unit the average of 3 penetrations	2. Pour sampl	2. Pour sample into heated rings. Total time from this point not to exceed 240 min.	
whose values do not differ by more than the following:	3. Cool, at am	3. Cool, at ambient, for 30min. Trim excess w/heated spatula.	
Pen range: <u>0-49</u> <u>50-149</u>	4. Assemble a	4. Assemble apparatus (w/steel balls at bottom); fill w/water to 105mm depth; retum to refrig	
Max difference b $\frac{2}{}$	or ice bath for 15 min	15 min	
highest & lowest penetration result	5. Apply heat	5. Apply heat at 5°C/min. After first 3min, max. variation is +/-0.5°C	
	6. If the differe	6. If the difference between the two temperatures exceeds $1^{\circ}C$ ($2^{\circ}F$), repeat the test.	
	7. When using	7. When using a 15C or 15F thermometer (low temp range), then report to nearest 0.2 $^\circ$ C (0.5 $^\circ$ F)	
	<u>.</u>		

10-17749 Ergon

Source:

				Autom	nated M	lixing 1	est								
Mix:	M1	Agg:	Table I	Mtn	Emul:	Ralum	ac								
Trial #	Temp°C	Cement, %	α Water, %	C Liquid Add, %:	Emulsion, %	Aggregate, g	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state torque	Mix Time: time where steady increas of torque begins	Spread Time: time where torque reaches 12 N-cm	Time when mix has broken	
1	25	0.5	8	0	10	300	1.5	24	0	30	n/a	n/a	n/a	>15 sec	
2 3 4 5 6	25	0	10	1	11	300	0	30	3	33	8.8	2:30	3:00	3:30	
3	25	0	12	1	11	300	0	36	3	33	8.8	3:45	6:15	7:30	
4	25	0	12	1	12	300	0	36	3	36	8.8	3:45	6:15	7:30	
5	25	0	12	1	12	300	0	36	3	36	8.8	5:00	7:30	8:45	
6	25	0	12	1	13	300	0	36	3	39	7.8	6:15	8:45	10:00	
7	25	0	12	1	14	300	0	36	3	42	7.5	6:15	8:45	10:00	
8	25	0	0	0	0	300	0	0	0	0					
Humid	ity= 50%	%													

						Autom	ated M	lixing 1	est						
Mix:	M2	Agg:	Table	Mtn	Emul:	LMCQ	S-1h								
Trial #	Temp °C	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Aggregate, g	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state torque			Time when mix has broken	
1	25	0	14		11	300	0	42	3	33		2:30	8:15	9:00	
2	25	0	14		14	300	0	42	3			n/a	n/a	n/a	
3	25	0	14	1	14	300	0	42	3	42	9.5			10:00	
4	25	0	12		15	300	0	36	3	45	8.8	10:00	n/a	10:00	
5	25	0	13	0.5	12	300	0	39	1.5	36	9.5	5:00	8:45	10:00	
6	25	0	12	0.5	12	300	0	36	1.5	36	9.5	3:45	7:30	8:45	****
2 3 4 5 6 7	25	0	12	1	11	300	0	36	3	33	9.5	3:45	7:30	8:00	
8	25	0	10	1	11	300	0	30	3	33	9.5	3:15	7:30	8:00	
Humid	ity= 509	%													
					*	aborte	d; LV;	rocks i	nterfer	ing wit	h stirre	er			
		_			**	didn't	break;	stoppe	ed at 10) min	_				
					***	stoppe	ed at 10) min							

				Autom	ated M	lixing 1	Test								
Mix:	МЗ	Agg:	Lopke		Emul:	Ralum	ac								
Trial #	25 Temp °C	Cement, %	Water, %	Ciquid Add, %:	Emulsion, %	Aggregate, g	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state torque	Mix Time: time where steady increas of torque begins	Spread Time: time where torque reaches 12 N-cm	Time when mix has broken	
1	25	0	12	0	10	300	0	36	0	30	8.5	2:30	7:30	8:45	
2	25	0.5	12		10	300	1.5	36	0	30	9	1:15	6:15	7:30	
3	25	1	14	1	10	300	3	42	3	30	9	1:15	7:00	7:30	
4	25	0	12	0	12	300	0	36	0	36	8.5	3:45	7:30	8:45	
5	25	0.5	12	0	12	300	1.5	36	0	36	8	2:30	6:15	7:30	
2 3 4 5 6 7	25	1	14	1	12	300	3	42	3	36	8	2:30	7:30	8:45	
		0	0	0	0	300	0	0	0	0					
8	25	0	0	0	0	300	0	0	0	0					
Humid	ity= 50%	%													

				Autom	nated M	lixing 1	est								
Mix:	M4	Agg:	Lopke		Emul:	LMCQ	S-1h								
Trial #	Temp℃	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Aggregate, g	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state torque	Mix Time: time where steady increas of torque begins	Spread Time: time where torque reaches 12 N-cm	Time when mix has broken	
1	25	1	16	0	11	300	3	48	0		7-8	8:15	>10	>10	
2 3 4	25	1	14	0	11	300	3	42	0		8-9	6:15		>10	
3	25	1	12	0	11	300	3	36			9-10	5:00		>10	
4		1	10	0	11	300	3	30			2-3	6:15		>10*	
4r	25	1	10	0	11	300	3	30				5:00			
5	25	1	9	0.5	11	300	3	27	1.5		10	2:30	3:00	3:00	
						300	0	0	0						
						300	0	0	0	0					
Humid	ity= 509	%					*	low to	rque b	c stirre	er wasr	n't set l	ow end	ough	

				Autom	ated N	lixing 1	est								
Mix:	M5	Agg:	Texas		Emul:	Ergon									
Trial #	25 Temp &	Cement, %	Water, %	Ciquid Add, %:	Emulsion, %	Aggregate, g	Cement, %	Water, %	Liquid Add, %:	Emulsion, %	Mix Index: steady state torque	Mix Time: time where steady increas of torque begins	Spread Time: time where torque reaches 12 N-cm	Time when mix has broken	
1	25	0	9	0	12	300	0	27	0	36	7.2	2:30	5:00	7:30	
2	25	0.5	9	0	12	300	1.5	27	0	36	7.5	2:15	4:30	7:30	
3	25	0	9	0	10	300	0	27	0	30	8.5	2:30	4:30	6:15	
4	25	0.5	9	0	10	300	1.5	27	0	30	8.5	2:30	4:00	6:15	
5	25	0	10	0	10	300	0	30	0	30	9	2:30	5:00	7:30	
2 3 4 5 6 7	25	0.5	10	0	10	300	1.5	30	0	30	9	2:15	4:30	7:30	
7		0	11	0	8	300	0	33	0	24	8.5	2:15	5:00	7:30	
8	25	0.5	11	0	. 8	300	1.5	33	0	24	8.5	1:45	3:45	6:15	
Humid	ity= 50%	%													

	aking			M1					ooks poor										no	C=A-B	Loss	Wt, g	659.5	602.3	551.7	441.0	346.5	543.4	383.7	214.0
emulsion	2)record weight of specimen after cure, before soaking		,						Comments: binding between emulsion and rock looks poor										yes	<u>a</u>	Final	Wt, g	1058.7	1114.5	1154.7	1291.6	1377.1	1184.7	1344.6	1549
and break	men after c	ith water		ml of water	owel	t,			veen emulsi			38	96				1 hour		ing	Temp	of SOAK	water	16	16	16	16	16	16	16	16
1)apply tack coat to disc and break emulsion	ight of speci	3)cover test specimen with water	r 60 sec	5)rinse debris with 1000ml of water	6)carefully pat dry with towel	7)record weight after test			binding bet			52	<i>LL</i>		06		1 minute		before test	Temp	of SOAK	water	61	61	61	61	9	09	09	09
1)apply tack	2)record we	3)cover test	4)abrade for 60 sec	5)rinse debr	6)carefully p	7) record we			Comments:			15	29		92		testing		Compaction w/ roller immediately before testing	Soaking	Period	before test	1 min	1 hour	1 hour					
										nditions:		re, ℃	re, °F		%		Soaking period before testing		n w/ roller i	Rolled @	end of cure Period	yes / no	ON	YES	ON	YES	ON	YES	ON	YES
			als			e 2				Curing Conditions:		Temperature, ℃	Temperature, ⁰F		Humidity, %		Soaking pe		Compactio		Humidity		51	51	48	20	48	51	48	48
		Ralumac	Sem Materials			cement type 2	alum.sulf.				SIS									End	Clock	Time	13:15	13:30	10:00	9:30	11:15	11:00	11:30	11:00
		Emulsion:	Source:			0.0 Additive:	1.00 Additive:	Additive:	Additive:		Cohes. Abrasion w/wheels		agg	cement		water	alum.sulf.	emulsion			Temp	ပွ	16	16	16	16	16	16	15	16
	Slurry/Micro Mix Design			11.0	12.0	0.0	1.00				Cohes.Abra	weights,g	1350.0	0.0		162.0	13.5	148.5			Temp	ĥ	09	09	09	09	09	09	29	09
	Slurry/Micro		untain	get:	e target:	::	et:	et:	;;					Э				arget)		Start	Clock	Time	12:45	13:00	00:6	8:30	8:15	8:00	6:30	00:9
10-17749	ne:	Type 3	Table Mor	Emulsion mid-range target:	Pre-wet water mid-range	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:	Additive mid-range target:			material	aggregate	0.0 cement / lim	Other:	12.0 water	1.0 alum.sulf.	11.0 emulsion (target)	Other:	Cure	Time	minutes	0:30	0:30	1:00	1:00	3:00	3:00	5:00	5:00
CEL#:	Project Name:	Aggregate: Type	Source:	Emulsion m	Pre-wet wat	Additive mic	Additive mic	Additive mic	Additive mic			%	:	0.0		12.0	1.0	11.0		A	Original	Wt, g	1718.2	1716.8	1706.4	1732.6	1723.6	1728.1	1728.3	1763.0

CEL#:	10-17749							1)apply tack	l)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	<u>men after ต</u>	2)record weight of specimen after cure, before soaking	aking
Project Name:	me:			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mountain	untain		Source:	Sem Materials	als		4)abrade for 60 sec	r 60 sec		1	
nulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M1
e-wet wa	Pre-wet water mid-range target:	target:	12.0					6)carefully p	6)carefully pat dry with towel	owel		
dditive mi	Additive mid-range target:	:t:	0.0	0.0 Additive:	cement type 2	5 2		7)record we	7)record weight after test	**		
dditive mi	Additive mid-range target:	::	1.0	1.0 Additive:	alum.sulf.							
dditive mi	Additive mid-range target:	;;		Additive:								
dditive mi	Additive mid-range target:	;;		Additive:				Comments:	binding bet	veen emulsi	Comments: binding between emulsion and rock looks poor	ooks poor
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sls.							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
:	aggregate		1350.0	agg		Temperature, °F	re, ℉	29	77	36		
0.0	0.0 cement / lime	ē	0.0	cement								
	Other:					Humidity, %	%	50	06			
12.0	2.0 water	-	162.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	irget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
			•								•	•
	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1777.2	0:30	12:00	90	16	12:30	06	NO	1 min	90	16	922.1	855.1
1752.3	3 0:30	12:15	61	16	12:45	88	YES	1 min	90	16	929.1	823.2
1762.8	1:00	9:45	90	16	10:45	88	NO	1 min	60	16	988.9	773.9
1785.0	1:00	9:35	90	16	10:35	88	YES	1 min	90	16	999.3	785.7
1742.9	3:00	8:15	59	15	11:15	88	NO	1 min	60	16	1113.9	629.0
1739.1	3:00	8:00	59	15	11:00	88	YES	1 min	59	15	1121.4	617.7
1756.8	3 5:00	5:45	09	16	10:45	06	NO	1 hour	60	16	1264.6	492.2
1759.2	5:00	5:30	90	16	10:30	06	YES	1 hour	90	16	1278.1	481.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	le:	Slurry/Micro Mix [Mix Design					2)record we	2)record weight of specimen after cure, before soaking	men after cu	ıre, before so	aking
Aggregate: Type	Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mountain	ountain		Source:	Sem Materials	ərials		4)abrade for 60 sec	r 60 sec		•	
Emulsion mid-range target:	id-range ta	rget:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M1
Pre-wet water mid-range target:	er mid-ran	ge target:	12.0					6)carefully p	6)carefully pat dry with towel	owel		
Additive mid-range target:	հ-range tar ը	get:	0.0	0.0 Additive:	cement type 2	e 2		7)record we	7)record weight after test	+		
Additive mid-range target:	ป-range tarเ	get:	1.0	1.0 Additive:	alum.sulf.							
Additive mid-range target:	հ-range tar ը	get:		Additive:								
Additive mid-range target:	հ-range tar ը	get:		Additive:				Comments:	Comments: binding between emulsion and rock looks poor	veen emulsi	on and rock	ooks poor
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whe	els		Ç	1	L	C		
%	material		weights,g			ا emperature, ک	e, c	GL	Q 7.	8		
1	aggregate		1350.0	agg		Temperature, ⁰F	re,°F	59	77	95		
0.0	0.0 cement / lime	me	0.0	cement								
	Other:					Humidity, %	%	50	06			
12.0	12.0 water		162.0	water								
1.0	I.0 alum.sulf.		13.5	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	'target)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
_<	2	t c t C			т Ц			Cooking	Tomb	Tomor	<u> </u>	
	ם כ	סומונ			2		e pallou	SOANIIG	2	<u></u>	ם	ם ל
Original	Time	Clock	Lemp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1722.5	0:30	12:00	78	26	12:30	49	ON	1 min	78	26	1401.5	321.0
1743.3	0:30	12:15	78	26	12:45	49	YES	1 min	78	26	1439.5	303.8
1759.1	1:00	9:30	92	24	10:30	20	NO	1 min	77	25	1453.4	305.7
1749.5	1:00	9:15	76	24	10:15	20	YES	1 min	77	25	1466.1	283.4
1768.2	3:00	8:30	77	25	11:30	20	ON	1 min	77	25	1649.8	118.4
1740.0	3:00	8:00	77	25	11:00	20	YES	1 min	77	25	1664.7	75.3
1772.1	5:00	6:15	78	26	11:15	50	ON	1 hour	77	25	1758.2	13.9
1769.1	5:00	5:45	78	26	10:45	50	YES	1 hour	77	25	1758.9	10.2

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix	Mix Design					2)record we	2)record weight of specimen after cure, before soaking	men after cu	ıre, before so	aking
Aggregate: Type	Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mountain	untain		Source:	Sem Materials	als		4)abrade for 60 sec	r 60 sec			
Emulsion m	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M1
Pre-wet wa	Pre-wet water mid-range target:	target:	12.0					6)carefully p	6)carefully pat dry with towel	owel		
Additive mic	Additive mid-range target:	;;	0.0	0.0 Additive:	cement type 2	3 2		7)record we	7)record weight after test			
Additive mic	Additive mid-range target:	;;	1.0	1.0 Additive:	alum.sulf.							
Additive mic	Additive mid-range target:	;;		Additive:								
Additive mic	Additive mid-range target:	;;		Additive:				Comments:	Comments: binding between emulsion and rock looks poor	veen emulsi	on and rock	ooks poor
						Curing Conditions:	nditions:					
;			Cohes. Abras	s. Abrasion w/wheels	els		(
%	material		weights,g			Temperature, °C	re, ګ	15	25	35		
1	aggregate	•	1350.0	agg		Temperature, ℉	re,°F	59	77	95		
0.0	0.0 cement / lime	Φ	0.0	cement								
	Other:					Humidity, %	%	20	06			
12.0	12.0 water		162.0	water								
1.0	1.0 alum.sulf.	•	13.5	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	ırget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	. ↓	့်ပ	Time	•	yes / no	before test	water	water	Wt, g	Wt, g
1724.3	0:30	12:00	92	24	12:30	90	NO	1 min	75	24	777.1	947.2
1751.9	0:30	12:15	75	24	12:45	06	YES	1 min	75	24	816.2	935.7
1711.6	1:00	9:45	77	25	11:45	89	ON	1 min	77	25	595.2	1116.4
1772.9	1:00	9:25	92	24	11:25	89	YES	1 min	73	23	857.1	915.8
1763.1	3:00	8:30	92	24	11:30	89	ON	1 min	92	24	913.6	849.5
1724.1	3:00	8:00	77	25	11:00	89	YES	1 min	74	23	1082	642.1
1770.4	5:00	6:15	78	56	11:15	88	ON	1 hour	74	23	895.4	875.0
1789.5	5:00	5:45	78	26	10:45	88	YES	1 hour	75	24	1266.3	523.2

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mountain	untain		Source:	Sem Materials	als		4)abrade for 60 sec	r 60 sec		•	
Emulsion r	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M1
Pre-wet wa	Pre-wet water mid-range target:	target:	12.0					6)carefully p	6)carefully pat dry with towel	owel		
Additive m	Additive mid-range target:	; ;;	0.0	0.0 Additive:	cement type 2	5.2		7)record we	7)record weight after test	+		
Additive m	Additive mid-range target:	∺	1.0	1.0 Additive:	alum.sulf.							
Additive m	Additive mid-range target:	₩.		Additive:								
Additive m	Additive mid-range target:	;;		Additive:				Comments:	binding betv	veen emulsi	Comments: binding between emulsion and rock looks poor	ooks poor
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SIS							
%	material		weights,g			Temperature, °C	re, °C	15	25	35		
:	aggregate		1350.0	agg		Temperature, ⁰F	re, °F	59	77	96		
0.0	0.0 cement / lime	Ф	0.0	cement								
	Other:					Humidity, %	%	50	96			
12.0	2.0 water	-	162.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	ırget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
,	•	•										•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1774.1	0:30	13:00	94	34	13:30	20	NO	1 min	94	34	1689.5	84.6
1777.8	3 0:30	12:50	92	35	13:20	49	YES	1 min	91	33	1680	97.8
1785.5	5 1:00	9:00	94	34	10:00	20	NO	1 min	91	33	1726.4	59.1
1815.9	9 1:00	8:30	94	34	9:30	49	YES	1 min	90	32	1776.9	39.0
1738.0	3:00	8:00	06	32	11:00	20	ON	1 min	94	34	1714.6	23.4
1750.3	3 3:00	7:30	94	34	10:30	20	YES	1 min	94	34	1717.1	33.2
1688.5	5 5:00	7:00	94	34	12:00	49	ON	1 hour	91	33	1686.5	2.0
1744.0	5:00	6:30	92	33	11:30	49	YES	1 hour	91	33	1741.6	2.4

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mountain	untain		Source:	Sem Materials	als		4)abrade for 60 sec	. 60 sec			
:mulsion r	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M1
re-wet wa	Pre-wet water mid-range target:	e target:	12.0					6)carefully p	6)carefully pat dry with towel	owel		
dditive m	Additive mid-range target:	;;	0.0	0.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+		
dditive m	Additive mid-range target:	:;:	1.0	1.0 Additive:	alum.sulf.							
dditive m	Additive mid-range target:)t:		Additive:								
dditive m	Additive mid-range target:)t:		Additive:				Comments:	binding betv	veen emulsi	Comments: binding between emulsion and rock looks poor	ooks poor
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sls							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
:	_aggregate		1350.0	agg		Temperature, °F	re,°F	69	77	96		
0.0	0.0 cement / lime	je je	0.0	cement								
	Other:					Humidity, %	9	20	90			
12.0	2.0 water	•	162.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
	•	•				•		•	•		٠	•
	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	⊹	ိင	Time		yes / no	before test	water	water	Wt, g	Wt, g
1748.7	7 0:30	12:00	96	36	12:30	88	ON	1 min	96	36	1520.8	227.9
1729.9	9 0:30	12:15	96	36	12:45	88	YES	1 min	96	36	1512.1	217.8
1740.7	7 1:00	9:45	92	35	10:45	89	NO	1 min	95	35	1620.7	120.0
1766.2	1:00	9:35	92	35	10:35	88	YES	1 min	95	35	1653.8	112.4
1768.9	3:00	8:30	92	35	11:30	88	NO	1 min	92	35	1711.6	57.3
1754.6	3:00	8:00	92	35	11:00	88	YES	1 min	95	35	1690.5	64.1
1750.3	3 5:00	6:15	94	34	11:15	89	ON	1 hour	95	35	1721.5	28.8
1747.3	3 5:00	5:45	94	34	10:45	89	YES	1 hour	94	34	1721.8	25.5

CEL#:	-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:		Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cı	2)record weight of specimen after cure, before soaking	aking
Aggregate: Type	: Type 3			Emulsion:	LMCQS-1h	lh I		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn			Source:	VSS Emultech	ho+		4)abrade for 60 sec	. 60 sec		•	
Emulsion n	Emulsion mid-range target:	let:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M2
Pre-wet wa	Pre-wet water mid-range target:	target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		-
Additive mi	Additive mid-range target:	ټ	0.0	0.0 Additive:	cement type 2	÷ 2		7)record we	7)record weight after test	+:		
Additive mi	Additive mid-range target:	ن <u>ن</u>	1.00	1.00 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	ن <u>د</u>		Additive:			_					
Additive mi	Additive mid-range target:	نن		Additive:				Comments:				
						Curing Conditions:	nditions:					
			Cohes.Abra	s.Abrasion w/wheels	SIS							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
;	aggregate	'	1350.0	agg		Temperature, ⁰F	re, ℉	69 20	77	95		
0.0	0.0 cement / lime	Ф	0.0	cement	٠							
	Other:					Humidity, %	%	50	06			
14.0	14.0 water	•	189.0	water	•						Ī	
1.0	1.0 alum.sulf.	'	13.5	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion								
	Other:	•				Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
		•	•			.=	. -		•		•	•
∢	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	Humidity end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	샤	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1777.6	3 0:30	11:45	61	16	12:15	49	>	1 min	60	16	924.9	852.7
1755.4	0:30	11:30	09	16	12:00	49	ON	1 min	60	16	1082.8	672.6
1787.8	1:00	9:45	59	15	10:45	49	>	1 min	60	16	1283.8	504.0
1749.4	1:00	9:30	59	15	10:30	49	ON	1 min	60	16	1295.9	453.5
1789.1	3:00	9:20	59	15	12:20	49	>	1 min	60	16	1392.6	396.5
1801.0	3:00	9:00	59	15	12:00	20	ON	1 min	60	16	1477	324.0
1783.6	5:00	7:00	59	15	12:00	20	>	1 hour	60	16	1571	212.6
1822.4	5:00	7:15	59	15	12:15	20	ON	1 hour	09	16	1480.4	342.0

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro	Slurry/Micro Mix Design					2)record we	ght of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:				Emulsion:	LMCQS-1h	h		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn	ı		Source:	VSS Emultech	ch		4)abrade for 60 sec	. 60 sec		•	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M2
Pre-wet wa	Pre-wet water mid-range target:	target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		7
Additive mi	Additive mid-range target:		0.0	0.0 Additive:	cement type 2	2		7)record we	7)record weight after test	ب		
Additive mi	Additive mid-range target:		1.0	1.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	<u>:</u>		Additive:								
Additive mi	Additive mid-range target:	َ نِنْ		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes.Abra	Cohes. Abrasion w/wheels	SIS							
%	material		weights,g			Temperature,	re, °C	15	25	35		
:	aggregate		1350.0	agg		Temperature, ⁰F	re, ℉	59	77	95		
0.0	0.0 cement / lime	Ф	0.0	cement	·							
	Other:					Humidity, %	,0	20	06			
14.0	14.0 water		189.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking pe	Soaking period before testing		1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion								
	Other:					Compaction	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
						•		,	•			,
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	<u>о</u>	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	Humidity end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Ļ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1637.8	0:30	11:35	59	15	12:05	89	\	1 min	58	14	9.008	837.2
1640.6	0:30	11:25	59	15	11:55	89	NO	1 min	59	15	679.6	961.0
1577.6	1:00	8:20	59	15	9:20	901	\	1 min	59	15	679.4	898.2
1634.2	1:00	8:00	58	14	9:00	90	NO	1 min	59	15	844.7	789.5
1701.5	3:00	7:00	09	16	10:00	91	\	1 min	58	14	1450.5	251.0
1673.2	3:00	6:45	09	16	9:45	91	NO	1 min	59	15	1231.9	441.3
1753.2	5:00	6:15	59	15	11:15	90	Υ	1 hour	58	14	1494.2	259.0
1710.4	5:00	6:00	59	15	11:00	90	NO	1 hour	59	15	1530.2	180.2

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix Design	Mix Design					2)record we	ight of speci	men after cเ	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 3			Emulsion:	LMCQS-1h	l		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn	_		Source:	VSS Emultech	Itech		4)abrade for 60 sec	r 60 sec			
Emulsion m	Emulsion mid-range target:	jet:	11.0					5)rinse debı	5)rinse debris with 1000ml of water	ml of water	'	M2
Pre-wet wat	Pre-wet water mid-range target:	target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		လ
Additive mid	Additive mid-range target:	ή:	0.0	0.0 Additive:	cement type 2	5.2		7)record we	7)record weight after test	+		
Additive mid	Additive mid-range target:	¥:	1.0	.0 Additive:	alum.sulf.							
Additive mid	Additive mid-range target:	¥:		Additive:								
Additive mid	Additive mid-range target:)t:		Additive:				Comments:				
		=				Curing Conditions:	ditions:					
			Cohes. Abra	Cohes. Abrasion w/wheels	sls		!	<u> </u>		1		
%	material		weights,g			Temperature,	re, င	15	25	35		
1	aggregate	•	1350.0	agg		Temperature, ⁰F	re, °F	59	77	95		
0.0	0.0 cement / lime	e	0.0	cement								
	Other:					Humidity, %	9	92	06			
14.0	14.0 water		189.0	water								
1.0	1.0 alum.sulf.	<u>-</u>	13.5	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	mmediately	Compaction w/ roller immediately before testing	ing	yes	no
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	℉	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1730.3	0:30	11:35	78	26	12:05	52	>	1 min	77	25	1176.9	553.4
1745.0	0:30	11:25	78	26	11:55	52	ON	1 min	77	25	1158.4	586.6
1752.7	1:00	8:25	77	25	9:25	52	>	1 min	77	25	1240.8	511.9
1762.1	1:00	8:00	77	25	9:00	52	ON	1 min	77	25	1164.6	597.5
1760.8	3:00	7:00	77	25	10:00	51	>	1 min	77	25	1225.2	535.6
1755.3	3:00	6:45	77	25	9:45	52	ON	1 min	77	25	1167.5	587.8
1759.3	5:00	6:15	77	25	11:15	54	>	1 hour	77	25	1469.3	290.0
1748.4	5:00	6:00	77	25	11:00	54	NO	1 hour	77	25	1397.8	350.6

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of specii	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 3			Emulsion:	LMCQS-1h	lh		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn	_		Source:	VSS Emultech)ch		4)abrade for 60 sec	. 60 sec		'	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M2
Pre-wet wa	Pre-wet water mid-range target:	e target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		4
Additive mi	Additive mid-range target:	:t:	0.0	0.0 Additive:	cement type 2	5.2		7)record we	7)record weight after test	+-		
Additive mi	Additive mid-range target:	:t:	1.0	1.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	;;		Additive:								
Additive mi	Additive mid-range target:	;;		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes.Abra	s.Abrasion w/wheels	SIS							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
1	aggregate	•	1350.0	agg		Temperature, ⁰F	re, ⁰F	59	77	95		
0.0	0.0 cement / lime	<u>е</u>	0.0	cement								
	Other:					Humidity, %	9	20	90			
14.0	14.0 water	•	189.0	water								
1.0	1.0 alum.sulf.	•	13.5	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion							_	
	Other:					Compactio	n w/ roller i	mmediately	Compaction w/ roller immediately before testing	ing	yes	no
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	<u>B</u>	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ት	Ç	Time		yes / no	before test	water	water	Wt, g	Wt, g
1743.6	0:30	11:55	78	26	12:25	92	>	1 min	79	26	1090	653.6
1752.8	3 0:30	12:10	78	26	12:40	92	ON	1 min	79	26	1114.7	638.1
1849.3	1:00	9:30	77	25	10:30	92	>	1 min	79	26	1299.6	549.7
1868.1	1:00	8:20	77	25	9:20	92	ON N	1 min	79	26	1432.6	435.5
1862.9	3:00	7:50	77	25	10:50	92	>	1 min	79	26	1571.5	291.4
1877.5	3:00	7:15	77	25	10:15	92	ON N	1 min	79	26	1562.3	315.2
1857.1	5:00	6:00	77	25	11:00	92	>	1 hour	79	26	1718.8	138.3
1899.4	5:00	5:40	77	25	10:40	92	ON	1 hour	79	26	1762.6	136.8

CEL#:	10-17749		ı					1)apply tack	1)apply tack coat to disc and break emulsion	and break	əmulsion	
Project Name:	ne:	Slurry/Micre	Slurry/Micro Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	-			Emulsion:	LMCQS-1h	h		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn	_		Source:	VSS Emultech	ch		4)abrade for 60 sec	. e0 sec		•	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M2
Pre-wet wa	Pre-wet water mid-range target:	target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		2
Additive mi	Additive mid-range target:	₩	0.0	0.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	ب		
Additive mi	Additive mid-range target:	∺	1.0	1.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	∺		Additive:								
Additive mi	Additive mid-range target:	∺		Additive:				Comments:	tests 1-4 do	ne on 10/05	Comments: tests 1-4 done on 10/05; tests 5-8 done on $10/0^2$	ne on 10/0z
ļ					Ī	Curing Conditions	ditions:					
			Cohes.Abra	Abrasion w/wheels	sle							
%	material		weights,g			Temperature,	re, ℃	15	25	35		
:	aggregate		1350.0	agg		Temperature,	re, ⁰F	29	77	96		
0.0	0.0 cement / lime	<u>e</u>	0.0	cement								
	Other:					Humidity, %	6	20	90			
14.0	14.0 water		189.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
-	-		-						-		•	•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1790.4	0:30	10:35	96	36	11:05	48	Υ	1 min	91	33	1332	458.4
1792.2	0:30	10:20	96	36	10:50	48	NO	1 min	92	33	1396.6	395.6
1756.0	1:00	9:45	95	35	10:45	49	\	1 min	93	34	1360	396.0
1760.1	1:00	9:30	92	35	10:30	49	NO	1 min	92	33	1379.3	380.8
1781.4	3:00	7:15	93	34	10:15	49	Υ	1 min	93	34	1544.9	236.5
1769.5	3:00	7:00	93	34	10:00	49	NO	1 min	93	34	1539.6	229.9
1788.5	5:00	00:9	92	33	11:00	49	Υ	1 hour	93	34	1592.1	196.4
1748.6	5:00	5:45	92	33	10:45	49	NO	1 hour	93	34	1530.5	218.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro	Slurry/Micro Mix Design		ı			2)record we	ight of speci	men after cı	2)record weight of specimen after cure, before soaking	aking
Aggregate:	-			Emulsion:	LMCQS-1h	h		3)cover test	3)cover test specimen with water	ith water		
Source:	Table Mtn	1		Source:	VSS Emultech	ho:		4)abrade for 60 sec	r 60 sec		'	
Emulsion m	Emulsion mid-range target:	let:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M2
Pre-wet wa	Pre-wet water mid-range target:	target:	14.0					6)carefully p	6)carefully pat dry with towel	owel		9
Additive mi	Additive mid-range target:	نيد	0.0	0.0 Additive:	cement type 2	5 2		7)record we	7)record weight after test	#		
Additive mi	Additive mid-range target:	يد	1.0	1.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	نيد		Additive:								
Additive mi	Additive mid-range target:	نيد		Additive:				Comments:				
						Curing Conditions	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sle							
%	material		weights,g			Temperature, °C	re, °C	15	25	32		
:	aggregate		1350.0	agg		Temperature, ⁰F	re,°F	29	77	96		
0.0	0.0 cement / lime	Ф	0.0	cement								
	Other:					Humidity, %	9	09	06			
14.0	14.0 water		189.0	water								
1.0	1.0 alum.sulf.		13.5	alum.sulf.		Soaking period before testing	riod before		1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
									•			
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1749.9	0:30	12:00	91	33	12:30	88	>	1 min	88	31	934.1	815.8
1776.9	0:30	12:15	91	33	12:45	88	NO	1 min	88	31	1177.2	599.7
1786.1	1:00	9:15	92	33	10:15	88	>	1 min	87	31	1180	606.1
1797.3	1:00	9:00	92	33	10:00	88	NO	1 min	87	31	1174.1	623.2
1734.1	3:00	7:35	93	34	10:35	89	>	1 min	88	31	1121.5	612.6
1716.3	3:00	7:20	93	34	10:20	89	NO	1 min	88	31	1172.3	544.0
1773.9	5:00	6:15	93	34	11:15	89	>	1 hour	88	31	1539.6	234.3
1739.4	5:00	00:9	93	34	11:00	89	NO	1 hour	88	31	1388.3	351.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break (emulsion	
Project Name:	me:	Slurry/Micro Mix Do	Mix Design		1			2)record we	ight of specii	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	Sem Materials	als		4)abrade for 60 sec	. 60 sec		•	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M3
Pre-wet wa	Pre-wet water mid-range target:	target:	15.0					6)carefully p	6)carefully pat dry with towel	owel		_
Additive mi	Additive mid-range target:	;;	0.5	0.5 Additive:	cement type 2	2		7)record we	7)record weight after test	+.		
Additive mi	Additive mid-range target:);	0.00	0.00 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	;;		Additive:								
Additive mi	Additive mid-range target:	;;		Additive:				Comments:				
						Curing Conditions	ditions:					
			Cohes.Abra	Cohes. Abrasion w/wheels	Sle							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
-	aggregate	'	1350.0	agg		Temperature,	re, ℉	59	77	95		
9.0	0.5 cement / lime	<u>.</u> е	6.8	cement	,							
	Other:	-				Humidity, %	,	20	06			
15.0	15.0 water		202.5	water	-							
0.0	0.0 alum.sulf.	. '	0.0	alum.sulf.		Soaking pe	Soaking period before testing		1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion	•							
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
٨	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	사	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1798.0	0:30	12:10	62	17	12:40	49	Υ	1 min	61	16	1451.9	346.1
1784.4	4 0:30	12:05	61	16	12:35	49	NO	1 min	09	16	1451.2	333.2
1715.9	00:1	11:30	09	16	12:30	49	У	1 min	09	16	1425.9	290.0
1760.9	9 1:00	11:10	09	16	12:10	49	ON	1 min	09	16	1442.2	318.7
1755.0	3:00	7:30	09	16	10:30	49	У	1 min	09	16	1419.1	335.9
1794.1	3:00	7:00	09	16	10:00	49	ON	1 min	09	16	1478.4	315.7
1691.7	7 5:00	6:15	09	16	11:15	49	У	1 hour	09	16	1434.1	257.6
1736.2	2 5:00	6:00	60	16	11:00	49	NO	1 hour	09	16	1454.1	282.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro	Slurry/Micro Mix Design					2)record we	ight of speci	men after c	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	Sem Materials	als		4)abrade for 60 sec	. 60 sec		'	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M3
Pre-wet wa	Pre-wet water mid-range target:	target:	15.0					6)carefully p	6)carefully pat dry with towel	owel		7
Additive mi	Additive mid-range target:	÷	0.5	0.5 Additive:	cement type 2	3.2		7) record we	7)record weight after test	+-		
Additive mi	Additive mid-range target:	÷	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	∺		Additive:								
Additive mi	Additive mid-range target:	÷		Additive:				Comments:				
						Curing Conditions	ditions:					
			Cohes.Abra	Cohes. Abrasion w/wheels	sle							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
1	aggregate		1350.0	agg		Temperature,	re, ℉	59	77	95		
0.5	0.5 cement / lime	Ф	6.8	cement								
	-Other:					Humidity, 9	%	20	06			
15.0	15.0 water		202.5	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing		1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
	,								,		٠	•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ᇮ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1826.7	0:30	12:25	58	14	12:55	88	Υ	1 min	57	14	1367.3	459.4
1826.5	5 0:30	12:10	58	14	12:40	88	NO	1 min	57	14	1346.5	480.0
1816.5	5 1:00	9:15	58	14	10:15	88	Υ	1 min	56	13	1389.7	426.8
1813.9	1:00	9:00	58	14	10:00	87	NO	1 min	57	14	1378.4	435.5
1740.6	3:00	8:00	58	14	11:00	88	Υ	1 min	57	14	1369.4	371.2
1774.6	3:00	7:40	59	15	10:40	87	NO	1 min	57	14	1380	394.6
1760.6	5:00	7:20	59	15	12:20	88	Υ	1 hour	57	14	1477.1	283.5
1760.7	5:00	7:00	59	15	12:00	88	NO	1 hour	57	14	1482.8	277.9

Slurry/Micro Mix Design
Emulsion:
Source: Sem Materials
0.5 Additive: cement type 2
0.0 Additive: alum.sulf.
Additive:
Additive:
Cohes.Abrasion w/wheels weights,g
agg
cement
water
alum.sulf.
emulsion
End
Temp Clock
°C Time
26 13:25
26 13:10
25 10:15
25 10:00
26 11:00
25 10:40
25 12:20

Slurry/Micro Mix Design		- Gioli	ż	- Ralimac			1)apply tack 2)record we	1)apply tack coat to disc and break emulsion 2)record weight of specimen after cure, before soaking	and break men after of	emulsion <u>ure, before s</u>	oaking
Aggregate: Type 3			Emulsion:	Ralumac Som Materials	<u>.</u>		3)cover test specim	3)cover test specimen with water	ith water		
Source. Lopke	+	7	source.	Seill Mater	als		4)abrade 10 - 5)ringo dob	4)ablade loi oo sec Evinco dobric with 1000ml of wator	m of custor		M3
Emusion mortalige target. Pro-wet water mid-range target:	 + 0.00+) - 4						S) carefully pat dry with towel	mi oi watei		C.
Additive mid-range target:		5.5	O 5 Additive:	C edyt tree	C		7) record we	2) record weight after test	5 5 1		t
י ומוטמו י		Signature		cement type	7		י ופכסות אפ	יוטווו מווכו וכי	-		
Additive mid-range target:		0.0	0.0 Additive:	alum.sult.		1					
Additive mid-range target:			Additive:			1					
Additive mid-range target:			Additive:			1	Comments:				
					Curing Conditions:	nditions:					
material		Cohes. Abrasion w/wheels	sion w/whe	els -	Temperature °C	ر ا	15	25	35		
aggregate		1350.0	agg		Temperature, °F	re, ℉	59	77	95		
0.5 cement / lime	<i>a</i> •	6.8	ŏ							-	
Other:					Humidity, %	%	50	06			
15.0 water		202.5	water								
0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0 emulsion (target)	get)	148.5	emulsion								
Other:					Compactic	on w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
minutes	Time	Å	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
0:30	8:00	79	26	8:30	92	>	1 min	74	23	1604.1	270.2
0:30	7:40	77	25	8:10	91	ON	1 min	74	23	1640.5	249.1
1:00	7:15	78	26	8:15	92	>	1 min	75	24	1629.6	223.6
1:00	7:00	77	25	8:00	91	ON	1 min	75	24	1549.1	281.1
3:00	9:10	78	26	12:10	92	>	1 min	92	24	1512.9	253.7
3:00	9:00	79	26	12:00	92	ON	1 min	76	24	1515.8	240.4
5:00	6:30	78	26	11:30	91	>	1 hour	76	24	1409.5	302.6
5:00	6:15	79	26	11:15	91	NO	1 hour	76	24	1554.3	236.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	.me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	Sem Materials	als		4)abrade for 60 sec	. 60 sec		1	
Emulsion r	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M3
Pre-wet wa	Pre-wet water mid-range target:	target:	15.0					6)carefully p	6)carefully pat dry with towel	owel		2
Additive m	Additive mid-range target:	; :t:	0.5	0.5 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+		
Additive m	Additive mid-range target:	:t:	0.0	0.0 Additive:	alum.sulf.							
Additive m	Additive mid-range target:	;;		Additive:								
Additive m	Additive mid-range target:)t:		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SIS							
%	material		weights,g			Temperature, °C	re,°C	15	25	35		
:	aggregate	•	1350.0	agg		Temperature, ⁰F	re, °F	69	77	95		
0.5	0.5 cement / lime	<u>.</u> е	6.8	cement								
	Other:					Humidity, %	9	50	90			
15.0	5.0 water	•	202.5	water								
0.0	0.0 alum.sulf.	'	0.0	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
-		•	•					•	•		•	•
۷	Cure	Start			End		Rolled @	Soaking	Temp	Temp	<u>о</u>	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Ļ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1742.5	5 0:30	11:15	91	33	11:45	50	>	1 min	93	34	1569	173.5
1736.4	4 0:30	11:00	91	33	11:30	51	NO	1 min	92	33	1611.9	124.5
1759.6	3 1:00	8:15	91	33	9:15	49	\	1 min	92	33	1599.4	160.2
1737.7	7 1:00	7:45	92	33	8:45	49	ON	1 min	92	33	1613.5	124.2
1730.1	3:00	7:00	92	33	10:00	49	>	1 min	92	33	1646.2	83.9
1743.8	3:00	6:45	92	33	9:45	49	NO	1 min	93	34	1686.2	57.6
1723.5	5 5:00	5:45	91	33	10:45	50	>	1 hour	92	33	1666.9	56.6
1694.2	5:00	5:30	92	33	10:30	50	ON	1 hour	92	33	1634.5	59.7

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:		Slurry/Micro Mix	Mix Design		<u>-</u>			2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	<u>aking</u>
Aggregate:	Type 3			Emulsion:	Ralumac			3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	Sem Materials	als		4)abrade for 60 sec	r 60 sec		1	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M3
Pre-wet wa	Pre-wet water mid-range target:	target:	15.0					6)carefully p	6)carefully pat dry with towel	owel		9
Additive mi	Additive mid-range target:	; ;;	0.5	0.5 Additive:	cement type 2	3 2	-	7)record we	7)record weight after test	+=		
Additive mi	Additive mid-range target:	;	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	:		Additive:			-					
Additive mi	Additive mid-range target:	÷		Additive:			, .	Comments:				
						Curing Conditions:	nditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SIS							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
:	_aggregate		1350.0	agg		Temperature, ⁰F	re, ℉	59	77	96		
0.5	0.5 cement / lime	Ф	6.8	cement	•							
	Other:					Humidity, %	%	20	90			
15.0	5.0 water	•	202.5	water	•						_	
0.0	0.0 alum.sulf.	•	0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing :	1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactic	n w/ roller	Compaction w/ roller immediately before testing	before test	ing	yes	no
		•	•			. -		•			•	•
ϭ	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Å	၀ွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1766.7	0:30	12:10	94	34	12:40	91	>	1 min	92	33	1575.1	191.6
1766.3	3 0:30	12:05	92	33	12:35	06	NO	1 min	93	34	1560.7	205.6
1756.5	1:00	11:30	92	33	12:30	06	>	1 min	91	33	1569.3	187.2
1743.7	1:00	11:10	93	34	12:10	91	ON	1 min	90	32	1578.3	165.4
1749.6	3:00	7:30	95	33	10:30	06	>	1 min	90	32	1658.5	91.1
1774.6	3:00	7:00	92	33	10:00	06	ON	1 min	90	32	1697.2	77.4
1760.5	5:00	6:15	91	33	11:15	91	>	1 hour	89	32	1699	61.5
1762.6	5:00	6:00	91	33	11:00	91	NO	1 hour	90	32	1709.9	52.7

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	LMCQS-1h	모		3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	VSS Emultech	ech		4)abrade for 60 sec	. 60 sec		•	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet wa	Pre-wet water mid-range target:	target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		_
Additive mi	Additive mid-range target:	<u>:</u>	1.0	1.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+		
Additive mi	Additive mid-range target:	<u>:</u> :	0.00	0.00 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	پ		Additive:								
Additive mi	Additive mid-range target:	₩		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SIS							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
:	aggregate	•	1350.0	agg		Temperature, ⁰F	re, ⁰F	69 28	77	95		
1.0	1.0 cement / lime	Φ	13.5	cement							i	
	Other:					Humidity, %	9	50	90			
16.0	16.0 water	•	216.0	water				•			_	
0.0	0.0 alum.sulf.	. •	0.0	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
	•	•	•					•	•		•	•
∢	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1841.0	0:30	15:05	90	16	15:35	49	>	1 min	61	16	1266	575.0
1794.9	0:30	14:55	58	14	15:25	51	ON	1 min	61	16	1421.1	373.8
1806.2	1:00	13:50	90	16	14:50	48	>	1 min	62	17	1419.5	386.7
1789.7	7 1:00	13:20	59	15	14:20	48	ON	1 min	61	16	1438.2	351.5
1796.8	3 3:00	10:00	59	15	13:00	49	>	1 min	60	16	1394.9	401.9
1799.4	3:00	10:45	90	16	13:45	50	ON	1 min	60	16	1419.5	379.9
1826.3	3 5:00	5:30	61	16	10:30	50	>	1 hour	60	16	1452.6	373.7
1830.3	3 5:00	5:45	61	16	10:45	50	ON	1 hour	60	16	1401.6	428.7

CEL#:	10-17749		ı					1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro	Slurry/Micro Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 3			Emulsion:	LMCQS-1h	h		3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	VSS Emultech	ch		4)abrade for 60 sec	. e0 sec		,	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet wa	Pre-wet water mid-range target:	target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		7
Additive mi	Additive mid-range target:	#	1.0	1.0 Additive:	cement type 2	5 2		7)record we	7)record weight after test	+ -		
Additive mi	Additive mid-range target:	#	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	∺		Additive:								
Additive mi	Additive mid-range target:	∺		Additive:				Comments:				
					•	Curing Conditions:	ditions:					
			Cohes.Abra	Cohes. Abrasion w/wheels	SIS							
%	material		weights,g			Temperature,	re, °C	15	25	35		
-	aggregate		1350.0	agg		Temperature, ⁰F	re, ℉	59	77	95		
1.0	1.0 cement / lime	e	13.5	cement								
	Other:					Humidity, %	9	50	90			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing		1 minute	1 hour		
11.0	11.0 emulsion (target)	rrget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	<u>о</u> В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	Humidity end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Å	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1758.2	0:30	11:20	59	15	11:50	88	\	1 min	62	17	1075.5	682.7
1761.8	0:30	11:10	59	15	11:40	88	NO	1 min	62	17	1107.4	654.4
1764.6	1:00	7:55	57	14	8:55	88	\	1 min	61	16	1262.7	501.9
1750.0	1:00	7:40	57	14	8:40	87	NO	1 min	62	17	1230.7	519.3
1760.2	3:00	7:30	57	14	10:30	88	Υ	1 min	62	17	1304.4	455.8
1755.6	3:00	7:05	57	14	10:05	87	NO	1 min	61	16	1320.6	435.0
1785.1	5:00	6:30	57	14	11:30	89	Υ	1 hour	61	16	1358	427.1
1761.5	5:00	6:15	57	14	11:15	89	NO	1 hour	90	16	1323.3	438.2

CEL#:	10-17749		ı					1)apply tack	1)apply tack coat to disc and break emulsion	and break e	emulsion	
Project Name:	me:	Slurry/Micro Mix	o Mix Design					2)record we	ight of specii	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 3			Emulsion:	LMCQS-1h	١h		3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	VSS Emultech	ltech		4)abrade for 60 sec	r 60 sec			
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		က
Additive mi	Additive mid-range target:	: :	1.0	1.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+-		
Additive mi	Additive mid-range target:	: :	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	: :		Additive:								
Additive mi	Additive mid-range target:	: :		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sls							
%	material		weights,g			Temperature,	re, °C	15	25	32		
1	aggregate		1350.0	agg		Temperature, ℉	re, ⁰F	59	77	95		
1.C	1.0 cement / lime	<u>e</u>	13.5	cement								
	Other:					Humidity, %	9	50	90			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	mmediately	Compaction w/ roller immediately before testing	ing	yes	no
_∢	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1740.2	0:30	12:10	78	26	12:40	48	Υ	1 min	79	26	1423.5	316.7
1763.8	3 0:30	12:05	78	26	12:35	48	NO	1 min	79	26	1465.4	298.4
1766.4	1:00	11:30	78	26	12:30	48	>	1 min	79	26	1464.9	301.5
1784.1	1:00	11:10	78	26	12:10	48	NO	1 min	79	26	1437	347.1
1760.6	3:00	7:30	77	25	10:30	49	Υ	1 min	79	26	1576.2	184.4
1750.8	3:00	7:00	77	25	10:00	49	NO	1 min	79	26	1466.2	284.6
1748.6	5:00	6:15	77	25	11:15	50	Υ	1 hour	78	26	1532.4	216.2
1766.0	5:00	9:00	77	25	11:00	50	NO	1 hour	78	26	1508.6	257.4

Project Name:		Shirry/Micro Mix	Mix Design					2)record we	2)record weight of specimen after cure, before soaking	men after ci		Zri Ye
		July/Iviliai o						71.0001.7		5	ire, betore so	aniig
Aggregate: Type	ype 3			Emulsion:	Emulsion: LMCQS-1h	L		3)cover test	3)cover test specimen with water	ith water		
Source: Lo	Lopke			Source:	VSS Emultech	ch		4)abrade for 60 sec	r 60 sec		•	
Emulsion mid-range target:	range targ€	et:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet water mid-range target:	mid-range	target:	16.0					6)carefully p	6)carefully pat dry with towel	wel		4
Additive mid-range target:	ange target	ı:	1.0	1.0 Additive:	cement type 2	2		7)record we	7)record weight after test	+		
Additive mid-range target:	ange target	ı:	0.0	0.0 Additive:	alum.sulf.							
Additive mid-range target:	ange target	1:		Additive:								
Additive mid-range target:	ange target	ا ::		Additive:				Comments:				
					_	Curing Conditions:	ditions:					
			Sohes.Abra	Cohes. Abrasion w/wheels	Slé							
, m	material	>	weights,g			Temperature, ℃	'e, °C	15	25	35		
ag	aggregate		1350.0	agg		Temperature, ⁰F	'e, °F	29	<u> </u>	95		
1.0 ce	1.0 cement / lime	en.	13.5	cement								
ō	Other:	l I				Humidity, %	,	20	06			
16.0 water	ater		216.0	water	•							
0.0 alt	0.0 alum.sulf.		0.0	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0 er.	11.0 emulsion (target)	rget)	148.5	emulsion								
Ö	Other:					Compaction	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	ou
<u>ا</u>	Cure	Start		_	End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1831.2	0:30	12:10	77	25	12:40	88	\	1 min	75	24	1365.1	466.1
1796.8	0:30	11:45	77	25	12:15	88	NO	1 min	75	24	1325	471.8
1843.1	1:00	9:15	78	26	10:15	89	Y	1 min	75	24	1442.5	400.6
1833.1	1:00	9:00	77	25	10:00	89	NO	1 min	75	24	1418.5	414.6
1841.8	3:00	7:45	77	25	10:45	90	Y	1 min	74	23	1526	315.8
1822.4	3:00	7:25	77	25	10:25	88	NO	1 min	74	23	1525.5	296.9
1845.7	5:00	6:30	77	25	11:30	88	\	1 hour	74	23	1598	247.7
1811.4	5:00	6:15	76	24	11:15	89	NO	1 hour	74	23	1587.7	223.7

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix Design	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 3			Emulsion:	LMCQS-1h	모		3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	VSS Emultech	ech		4)abrade for 60 sec	. 60 sec		!	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		5
Additive mi	Additive mid-range target:	:: :t:	1.0	1.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+-		
Additive mi	Additive mid-range target:	:: ::	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	:		Additive:								
Additive mi	Additive mid-range target:	بر: بر:		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sle							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
:	aggregate	•	1350.0	agg		Temperature, °F	re, ℉	29	77	95		
1.0	1.0 cement / lime	e e	13.5	cement								
	Other:					Humidity, %	%	20	90			
16.0	16.0 water	•	216.0	water								
0.0	0.0 alum.sulf.	'	0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
		•	•					•	•			,
۷	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1768.1	0:30	12:55	92	35	13:25	50	>	1 min	94	34	1514.2	253.9
1764.4	0:30	12:40	92	35	13:10	20	ON	1 min	93	34	1536.9	227.5
1755.9	1:00	9:15	93	34	10:15	51	>	1 min	93	34	1553.3	202.6
1740.9	1:00	9:00	92	33	10:00	51	ON	1 min	93	34	1522.5	218.4
1755.8	3:00	8:00	92	33	11:00	52	>	1 min	93	34	1593.4	162.4
1784.2	3:00	7:40	92	33	10:40	52	ON	1 min	93	34	1604.9	179.3
1761.7	5:00	7:20	92	33	12:20	52	Υ	1 hour	93	34	1623.6	138.1
1743.0	5:00	7:00	92	33	12:00	52	ON	1 hour	93	34	1597.9	145.1

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 3			Emulsion:	LMCQS-1h	모		3)cover test	3)cover test specimen with water	ith water		
Source:	Lopke			Source:	VSS Emultech	ech		4)abrade for 60 sec	. e0 sec		•	
Emulsion r	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M4
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		9
Additive m	Additive mid-range target:	:t:	1.0	1.0 Additive:	cement type 2	5.2		7)record we	7)record weight after test	+-		
Additive m	Additive mid-range target:	::	0.0	0.0 Additive:	alum.sulf.							
Additive m	Additive mid-range target:	:t:		Additive:								
Additive m	Additive mid-range target:)t:		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SIS							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
;	aggregate		1350.0	agg		Temperature, °F	re,°F	69	77	96		
1.0	1.0 cement / lime	e e	13.5	cement								
	Other:					Humidity, %	9	20	90			
16.0	16.0 water	•	216.0	water				•				
0.0	0.0 alum.sulf.	'	0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
	٠	•	•					•	•		•	•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ት	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1749.2	2 0:30	11:10	93	34	11:40	91	>	1 min	96	36	1443.5	305.7
1757.9	0:30	11:00	93	34	11:30	91	ON	1 min	96	36	1476.7	281.2
1784.0	0 1:00	7:45	92	33	8:45	89	>	1 min	94	34	1533.6	250.4
1756.3	3 1:00	7:30	92	33	8:30	89	ON	1 min	94	34	1487.8	268.5
1766.6	3:00	7:20	92	33	10:20	89	>	1 min	94	34	1547.8	218.8
1754.8	3:00	7:00	92	33	10:00	89	NO	1 min	93	34	1542.1	212.7
1765.2	2 5:00	6:30	92	33	11:30	91	>	1 hour	93	34	1579.9	185.3
1760.6	5:00	6:15	92	33	11:15	91	ON	1 hour	93	34	1593.3	167.3

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name	ne:	Slurry/Micro Mix D	Mix Design					2)record we	ight of speci	men after cเ	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 2/3			Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	lta		Source:	Ergon			4)abrade for 60 sec	. e0 sec		•	
Emulsion m	Emulsion mid-range target:	let:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		_
Additive mic	Additive mid-range target:	₩.	1.0	1.0 Additive:	cement type 2	5 2		7)record we	7)record weight after test	÷-		
Additive mic	Additive mid-range target:	ننه	0.00	0.00 Additive:	alum.sulf.							
Additive mic	Additive mid-range target:	نيد		Additive:								
Additive mic	Additive mid-range target:	ن <u>ن</u>		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes.Abra	Abrasion w/wheels	SIS							
%	material		weights,g			Temperature, ℃	re, ℃	15	25	35		
:	aggregate		1350.0	agg		Temperature, ℉	re, °F	59	77	95		
1.0	1.0 cement / lime	Ф	13.5	cement								
	Other:					Humidity, %	%	50	90			
16.0	16.0 water		216.0	water					•			
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	rget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
•		•	•					•			-	•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	Humidity end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ት	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1755.2	0:30	12:30	61	16	13:00	51	>	1 min	61	16	973	782.2
1764.8	0:30	12:45	61	16	13:15	51	ON	1 min	61	16	1003.4	761.4
1747.3	1:00	8:25	09	16	9:25	52	>	1 min	61	16	1035.3	712.0
1787.8	1:00	8:00	09	16	9:00	52	ON	1 min	61	16	1091.5	696.3
1745.8	3:00	7:00	58	14	10:00	52	>	1 min	59	15	1513.1	232.7
1722.3	3:00	6:45	58	14	9:45	52	ON	1 min	59	15	1446.9	275.4
1766.6	5:00	6:15	58	14	11:15	52	>	1 hour	59	15	1582.5	184.1
1748.9	5:00	6:00	58	14	11:00	52	ON	1 hour	59	15	1553	195.9

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix Design	Mix Design					2)record we	ight of specil	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 2/3	3		Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	∍lta		Source:	Ergon			4)abrade for 60 sec	. e0 sec		!	
Emulsion n	Emulsion mid-range target:	get:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		2
Additive mi	Additive mid-range target:	et:	1.0	1.0 Additive:	cement type 2	9.5		7)record we	7)record weight after test	+-		
Additive mi	Additive mid-range target:	et:	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	et:		Additive:								
Additive mi	Additive mid-range target:	et:		Additive:				Comments:				
		•				Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	SI6							
%	material		weights,g			Temperature, ℃	re, °C	15	25	32		
;	aggregate	•	1350.0	agg		Temperature, °F	re, ℉	69	77	95		
1.0	1.0 cement / lime	ne	13.5	cement								
	Other:					Humidity, %	%	20	90			
16.0	16.0 water	•	216.0	water								
0.0	0.0 alum.sulf.	'	0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before testi	ing	yes	no
			•					•	•		•	
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	ĥ	သ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1717.4	0:30	12:45	59	15	13:15	92	>	1 min	59	15	925.5	791.9
1667.8	0:30	12:35	59	15	13:05	91	ON	1 min	59	15	980.2	687.6
1756.0	1:00	8:15	58	14	9:15	91	>	1 min	58	14	1374.5	381.5
1693.5	1:00	8:00	58	14	9:00	92	ON	1 min	59	15	1261.8	431.7
1767.1	3:00	7:05	58	14	10:05	88	>	1 min	58	14	1499.7	267.4
1699.3	3:00	6:50	58	14	9:50	89	ON	1 min	59	15	1431.3	268.0
1688.1	2:00	6:20	09	16	11:20	92	\	1 hour	59	15	1517.7	170.4
1760.8	2:00	6:00	58	14	11:00	89	ON	1 hour	59	15	1591	169.8

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix	Mix Design		,			2)record we	ight of speci	men after cı	2)record weight of specimen after cure, before soaking	aking
Aggregate: Type	Type 2/3			Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	lta		Source:	Ergon			4)abrade for 60 sec	r 60 sec		!	
Emulsion n	Emulsion mid-range target:	jet:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		က
Additive mi	Additive mid-range target:	: :	1.0	1.0 Additive:	cement type 2	9.2		7)record we	7)record weight after test	+		
Additive mi	Additive mid-range target:	et:	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	et:		Additive:								
Additive mi	Additive mid-range target:	at:		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes.Abra	s.Abrasion w/wheels	sle							
%	material		weights,g			Temperature,	re,°C	15	25	35		
1	aggregate		1350.0	agg		Temperature, ⁰F	re,°F	59	77	95		
1.0	1.0 cement / lime	je e	13.5	cement								
	Other:					Humidity, %	%	20	06			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactic	n w/ roller	Compaction w/ roller immediately before testing	before test	ing	yes	no
_∢	Cure	Start			End		Rolled @	Soaking	Temp	Temp	8	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	Å	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1796.7	0:30	12:10	79	26	12:40	49	>	1 min	74	23	1468.1	328.6
1761.7	0:30	12:00	79	26	12:30	49	ON	1 min	74	23	1481	280.7
1711.1	1:00	10:10	77	25	11:10	20	>	1 min	74	23	1573.6	137.5
1762.9	1:00	9:50	77	25	10:50	50	ON	1 min	74	23	1610.5	152.4
1785.4	3:00	8:00	77	25	11:00	20	>	1 min	74	23	1708.3	77.1
1781.4	3:00	7:45	77	25	10:45	20	ON	1 min	74	23	1716.1	65.3
1761.4	5:00	6:05	92	24	11:05	52	>	1 hour	74	23	1681.8	79.6
1773.5	5:00	6:20	77	25	11:20	52	NO	1 hour	74	23	1710.5	63.0

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design		,			2)record we	ight of speci	men after cเ	2)record weight of specimen after cure, before soaking	aking
Aggregate: Type	Type 2/3			Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	lta		Source:	Ergon			4)abrade for 60 sec	r 60 sec		'	
Emulsion r	Emulsion mid-range target:	jet:	11.0					5)rinse debi	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		4
Additive m	Additive mid-range target:	:t:	1.0	1.0 Additive:	cement type 2	9.5		7)record we	7)record weight after test	+		
Additive m	Additive mid-range target:	: :	0.0	0.0 Additive:	alum.sulf.							
Additive m	Additive mid-range target:	:		Additive:								
Additive m	Additive mid-range target:	:: ::		Additive:				Comments:				
						Curing Conditions:	ditions:					
ļ			Cohes. Abrasion w/wheels	sion w/whe	sle		ļ		•	1	_	
%	material		weights,g			Temperature,	င့် (၁	15	25	35		
;	aggregate	-	1350.0	agg		Temperature, ⁰F	ře, ۴	59	77	95		
1.0	1.0 cement / lime	<u>e</u>	13.5	cement								
	Other:					Humidity, %	9	20	06			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.	-	0.0	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	mmediately	Compaction w/ roller immediately before testing	ing	yes	no
_ <	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	사	ပွ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1723.9	0:30	12:30	78	26	13:00	89	٨	1 min	76	24	1382.3	341.6
1733.5	6 0:30	12:45	78	26	13:15	06	NO	1 min	76	24	1382.7	350.8
1701.8	1:00	10:00	77	25	11:00	06	>	1 min	76	24	1447.8	254.0
1679.4	1:00	9:50	77	25	10:50	06	ON	1 min	76	24	1376.5	302.9
1729.4	3:00	8:10	77	25	11:10	06	>	1 min	76	24	1579	150.4
1715.8	3:00	7:45	77	25	10:45	06	ON	1 min	75	24	1560.1	155.7
1744.9	5:00	6:05	77	25	11:05	06	>	1 hour	76	24	1646.9	98.0
1730.3	5:00	6:20	77	25	11:20	06	NO	1 hour	76	24	1619.7	110.6

CEL#:	10-17749							1)apply tack	I)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	me:	Slurry/Micro Mix	Mix Design					2)record we	ight of speci	men after cu	2)record weight of specimen after cure, before soaking	aking
Aggregate:	: Type 2/3	က		Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	elta		Source:	Ergon			4)abrade for 60 sec	. 60 sec		•	
Emulsion r	Emulsion mid-range target:	rget:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	je target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		2
Additive m	Additive mid-range target:	jet:	1.0	1.0 Additive:	cement type 2	5.2		7)record we	7)record weight after test	+		
Additive m	Additive mid-range target:	jet:	0.0	0.0 Additive:	alum.sulf.							
Additive m	Additive mid-range target:	jet:		Additive:								
Additive m	Additive mid-range target:	jet:		Additive:				Comments:				
						Curing Conditions:	ditions:					
			Cohes. Abrasion w/wheels	sion w/whee	sls							
%	material		weights,g			Temperature,℃	re,°C	15	25	35		
1	aggregate		1350.0	agg		Temperature, ⁰F	re,°F	29	77	96		
1.0	1.0 cement / lime	me	13.5	cement								
	Other:					Humidity, %	9	50	90			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking period before testing	riod before	testing	1 minute	1 hour		
11.(11.0 emulsion (target)	target)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
,			,					•	•		٠	,
۷	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	♣	သ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1732.6	0:30	13:00	96	36	13:30	49	>	1 min	95	35	1681.9	50.7
1748.5	5 0:30	13:15	92	35	13:45	49	ON	1 min	95	35	1689	59.5
1736.8	1:00	9:45	92	35	10:45	50	>	1 min	95	35	1692.4	44.4
1761.6	1:00	9:30	92	35	10:30	50	ON	1 min	95	35	1714.7	46.9
1766.9	3:00	7:20	92	35	10:20	50	>	1 min	95	35	1762	4.9
1754.9	3:00	7:00	92	35	10:00	50	ON	1 min	95	35	1749.7	5.2
1737.1	2:00	6:00	92	35	11:00	50	>	1 hour	95	35	1735.7	1.4
1752.4	5:00	6:15	92	35	11:15	50	ON	1 hour	95	35	1751.3	1.1

CEL#:	10-17749							1)apply tack	1)apply tack coat to disc and break emulsion	and break	emulsion	
Project Name:	ne:	Slurry/Micro Mix Des	o Mix Design					2)record we	ight of speci	men after c	2)record weight of specimen after cure, before soaking	aking
Aggregate:	Type 2/3	~		Emulsion:	Micro			3)cover test	3)cover test specimen with water	ith water		
Source:	Texas Delta	elta		Source:	Ergon			4)abrade for 60 sec	r 60 sec		!	
Emulsion n	Emulsion mid-range target:	get:	11.0					5)rinse debr	5)rinse debris with 1000ml of water	ml of water		M5
Pre-wet wa	Pre-wet water mid-range target:	e target:	16.0					6)carefully p	6)carefully pat dry with towel	owel		9
Additive mi	Additive mid-range target:	ət:	1.0	.0 Additive:	cement type 2	2		7) record we	7)record weight after test	+		
Additive mi	Additive mid-range target:	et:	0.0	0.0 Additive:	alum.sulf.							
Additive mi	Additive mid-range target:	ət:		Additive:								
Additive mi	Additive mid-range target:	ət:		Additive:				Comments:				
						Curing Conditions	ditions:					
			Cohes.Abra	Cohes. Abrasion w/wheels	Sli							
%	material		weights,g			Temperature, ℃	re, °C	15	25	35		
-	aggregate		1350.0	agg		Temperature, ºF	re, ℉	29	77	96		
1.0	1.0 cement / lime	ЭС	13.5	cement								
	Other:					Humidity, %	9	09	06			
16.0	16.0 water		216.0	water								
0.0	0.0 alum.sulf.		0.0	alum.sulf.		Soaking pe	Soaking period before testing	testing	1 minute	1 hour		
11.0	11.0 emulsion (target)	arget)	148.5	emulsion								
	Other:					Compactio	n w/ roller i	Compaction w/ roller immediately before testing	before test	ing	yes	no
												•
⋖	Cure	Start			End		Rolled @	Soaking	Temp	Temp	В	C=A-B
Original	Time	Clock	Temp	Temp	Clock	Humidity	end of cure Period	Period	of SOAK	of SOAK	Final	Loss
Wt, g	minutes	Time	₽	သ	Time		yes / no	before test	water	water	Wt, g	Wt, g
1748.8	0:30	12:30	94	34	13:00	89	>	1 min	95	35	1670.9	77.9
1736.5	0:30	12:45	94	34	13:15	90	ON	1 min	95	35	1650.9	85.6
1717.8	1:00	8:25	94	34	9:25	06	>	1 min	94	34	1667.8	50.0
1760.2	1:00	8:00	94	34	9:00	90	NO	1 min	94	34	1715.5	44.7
1762.8	3:00	7:00	94	34	10:00	06	>	1 min	94	34	1751.5	11.3
1744.4	3:00	6:45	94	34	9:45	06	ON	1 min	94	34	1735.3	9.1
1738.4	2:00	6:15	93	34	11:15	90	>	1 hour	94	34	1738	0.4
1751.4	2:00	00:9	93	34	11:00	90	ON	1 hour	94	34	1750.3	1.1

Aggregates:

A1 Table Mountain (ISSA Type III)

A2 Lopke Gravel Products (ISSA Type III)

A3 Unknown: Texas Texas

Emulsions:

E1 Koch Ralumac

Polymer Modified LMCQS-1h, VSS

E2 Emultech

E3 Unknown: Ergon

Mixes:

M1 A1+E1 M2 A1+E2 M3 A2+E1 M4 A2+E2

M5 A3+E3, Unknown

TEST R	ESULTS	Mix	M1		M2		М3		M4		M5	
		Auto/Man	AUTO	MATIC	AUTO	MATIC	AUTO	MATIC	AUTO	MATIC	AUTO	MATIC
		Replicates	1	2	1	2	1	2	1	2	1	2
Humidity	Temp. ('C)	Curing(min)	TEMPLE	2047-01	TEMPLE	2047-01	TEMPLE	2047-01	TEMPLE	2047-01	TEMPLE	2047-01
50%	10	15	1.8 N	2.1 N	1.3 N	1.6 N	3.5 N	4.5 N	2.8 N	2.5 N	4.0 N	6.1 N
50%	10	30	2.1 N	2.3 N	1.9 N	2.0 N	4.9 N	5.0 N	3.6 N	2.8 N	5.0 N	4.7 N
50%	10	60	3.1 N	3.9 N	1.6 N	1.9 N	4.7 N	5.8 N	3.4 N	3.8 N	4.3 N	4.2 N
50%	10	90	2.7 N	3.2 N	2.1 N	1.6 N	7.2 N	8.5 N	3.3 N	3.0 N	3.0 N	4.9 N
50%	10	120	3.1 N	3.4 N	2.4 N	1.9 N	8.5 N	8.8 N	4.6 N	2.8 N	4.1 N	4.2 N
50%	10	180	4.9 N	4.9 N	2.3 N	2.1 N	8.9 NS	8.9 NS	4.5 N	6.9 N	5.6 N	5.2 N
50%	10	240	5.9 N	6.5 N	4.2 N	3.0 N	9.9 SS	9.5 S	11.9 SS	12.0 S	6.8 N	6.0 N
50%	25	15	2.5 N	3.3 N	1.9 N	1.3 N	8.8 N	8.0 N	3.1 N	2.7 N	4.7 N	5.5 N
50%	25	30	4.5 N	3.8 N	1.6 N	2.1 N	11.5 N	11.0 N	4.6 N	5.2 N	7.0 N	6.1 N
50%	25	60	7.2 N	4.3 N	2.4 N	2.2 N	9.4 S	9.9 NS	5.2 N	4.8 N	4.9 N	6.3 N
50%	25	90	8.6 NS	9.8 NS	3.9 N	3.8 N	13.1 S	11.1 S	6.0 N	5.9 N	7.6 N	7.7 N
50%	25	120	8.6 S	9.4 S	3.9 N	3.4 N	12.6 SS	11.0 SS	7.3 N	9.7 N	8.4 NS	9.8 NS
50%	25	180	11.9 SS	10.3 SS	5.5 N	4.9 N	17.7 SS	13.1 SS	8.1 S	10.0 S	6.6 S	11.2 S
50%	25	240	10.9 SS	11.8 SS	6.9 S	6.3 S	9.9 SS	15.8 SS	11.8 SS	9.5 SS	9.7 SS	12.8 SS
50%	35	15	2.2 N	2.0 N	3.0 N	3.1 N	8.2 N	7.6 N	3.1 N	3.1 N	6.3 NS	6.9 NS
50%	35	30	3.4 N	4.0 N	5.2 N	3.7 N	9.2 N	8.8 N	4.7 N	3.2 N	7.6 NS	9.6 NS
50%	35	60	3.9 N	4.3 N	5.3 N	5.2 N	10.2 NS	9.8 N	4.1 N	5.0 N	8.9 NS	8.0 NS
50%	35	90	6.6 N	6.2 N	8.1 NS	6.2 NS	12.0 S	13.3 S	5.6 N	3.8 N	9.6 NS	15.3 NS
50%	35	120	6.8 NS	9.0 NS	10.2 NS	8.0 NS	11.1 SS	10.1 SS	8.2 NS	8.8 NS	10.9 NS	10.1 S
50% 50%	35 35	180 240	13.9 S 14.4 SS	14.2 S 13.5 SS	15.0 S 12.7 SS	13.6 S 13.7 SS	11.1 SS 16.5 SS	9.7 SS 13.8 SS	11.4 S 12.7 SS	11.8 S 12.4 SS	10.2 S 13.5 SS	8.4 S 11.3 SS
90%	10	15		3.7 N	2.2 N	1.1 N	3.7 N	2.1 N	2.1 N	3.1 N	6.6 N	5.1 N
90%	10	30	1.8 N 2.8 N	2.1 N	1.8 N	1.1 N 1.8 N	3.7 N 3.6 N	3.1 N	2.1 N 2.7 N	2.2 N	5.2 N	4.6 N
90%	10	60	2.7 N	2.1 N	1.6 N	2.0 N	7.4 N	5.1 N	3.3 N	3.2 N	5.2 N	6.5 N
90%	10	90	3.9 N	4.2 N	1.0 N	1.8 N	8.0 N	8.0 N	3.4 N	2.1 N	4.6 N	5.1 N
90%	10	120	2.7 N	4.1 N	1.3 N	2.0 N	8.3 NS	8.3 N	2.8 N	2.1 N	3.6 N	6.2 N
90%	10	180	4.2 N	3.7 N	1.5 N	2.6 N	10.2 NS	10.9 NS	2.9 N	4.7 N	4.6 N	4.2 N
90%	10	240	6.9 N	6.8 N	2.9 N	1.6 N	8.6 SS	7.6 SS	3.6 N	4.6 N	5.7 N	5.1 N
90%	25	15	1.8 N	2.0 N	2.1 N	2.4 N	6.7 N	6.6 N	4.2 N	3.8 N	5.4 N	7.9 N
90%	25	30	2.8 N	2.2 N	1.7 N	1.5 N	7.6 N	7.6 N	3.7 N	3.6 N	7.0 N	6.7 N
90%	25	60	2.3 N	2.2 N	2.8 N	2.3 N	8.2 NS	8.7 NS	3.4 N	5.5 N	6.9 N	8.4 N
90%	25	90	2.2 N	2.0 N	2.1 N	2.7 N	11.7 S	10.8 S	5.8 N	5.8 N	7.8 N	8.7 N
90%	25	120	2.2 N	2.1 N	2.9 N	4.1 N	10.6 S	9.9 SS	5.3 N	6.2 N	8.2 N	6.8 N
90%	25	180	3.2 N	1.8 N	6.5 N	9.6 N	10.6 S	9.2 S	8.8 N	6.8 N	9.6 N	8.1 N
90%	25	240	3.5 N	3.4 N	10.6 NS	11.9 NS	10.5 SS	9.6 SS	11.5 N	7.9 N	7.9 NS	9.8 NS
90%	35	15	3.0 N	3.2 N	1.6 N	2.1 N	5.5 N	6.0 N	3.9 N	3.3 N	6.9 N	7.3 N
90%	35	30	2.0 N	2.7 N	2.5 N	1.9 N	5.3 N	7.1 N	4.1 N	3.5 N	7.3 N	6.7 N
90%	35	60	2.8 N	2.7 N	3.0 N	2.2 N	8.2 S	6.5 S	5.0 N	5.7 N	7.0 N	8.2 N
90%	35	90	4.2 N	5.6 N	3.8 N	3.9 N	5.6 SS	6.0 SS	4.6 N	4.6 N	8.0 N	7.2 N
90%	35	120	5.4 N	7.1 N	5.1 N	5.8 N	15.7 SS	14.4 SS	4.8 N	5.6 N	8.5 N	8.0 N
90%	35	180	10.4 NS	13.1 NS	6.1 N	5.7 N	11.9 SS	9.9 SS	4.4 N	6.0 N	9.2 N	7.8 N
90%	35	240	16.9 S	15.9 S	8.0 N	9.0 N	12.8 SS	15.8 SS	8.6 N	11.4 N	10.0 NS	11.7 NS

TEST	RESULTS	Mix	M1		M2		M3		M4		M5	
		Auto/Man	MAN	IUAL								
		Replicates	1	2	1	2	1	2	1	2	1	2
Humidity	Temp. ('C)	Curing(min)	ALPHA L	abs 3910								
50%	10	15			ì							
50%	10	30										
50%	10	60										
50%	10	90										
50%	10	120										
50%	10	180										
50%	10	240										
50%	25	15					15.0 N	14.0 N	10.0 N	11.0 N		
50%	25	30					16.0 N	15.0 NS	12.0 N	13.0 N		
50%	25	60					19.0 S	17.0 S	13.0 N	14.0 N		
50%	25	90					20.0 S	21.0 S	17.0 N	17.0 N		
50%	25	120					21.0 SS	21.0 SS	18.0 N	18.0 N		
50%	25	180					22.0 SS	23.0 SS	22.0 S	23.0 S		
50%	25	240					24.0 SS	24.0 SS	28.0 SS	26.0 SS		
50%	35	15									15.0 NS	16.0 NS
50%	35	30									19.0 NS	20.0 NS
50%	35	60									20.0 NS	21.0 NS
50%	35	90									20.0 NS	21.0 NS
50%	35	120									23.0 S	22.0 S
50%	35	180									23.0 SS	23.0 SS
50%	35	240									25.0 SS	26.0 SS
90%	10	15										
90%	10	30										
90%	10	60										
90%	10	90										
90%	10	120										
90%	10	180										
90%	10	240										
90%	25	15			7.0 N	9.0 N						
90%	25	30			9.0 N	9.0 N						
90%	25	60			11.0 N	9.0 N						
90%	25	90			12.0 N	10.0 N						
90%	25	120			12.0 N	12.0 N						
90%	25	180			14.0 NS	15.0 NS						
90%	25	240			16.0 NS	17.0 NS						
90%	35	15										
90%	35	30										
90%	35	60										
90%	35	90										
90%	35	120										
90%	35	180										
90%	35	240										

Parameter	Units	Values		Tes	t No.		
		High (H)	Low (L)	1	2	3	4
1. Cure Temp	С	2	-2	L	L	Η	Н
2. Cure Time	min	3	-3	L	I	L	Н
3. Cure Humidity	%	10	-10	Н	L	L	Н



Asphalt Classification Summary

Client: Pooled Fund Study
Project Name: Automated Cohesion Testing
Asphalt Products Testing

MACTEC Job No.: 5016-03-0007 Date Reported: 05-08-2008 Material: PMCQS-1h Source: SemMaterials, L.P.

	Pr	oject No.:	NP	
		mple ID.:	NP	
		Lab No.:	830440	
		Received:	04-14-2008	
	San	nple Date:	NP	
		ple Type:	Concentrate	
Tests on Emulsions	Test Method	Spec		
Saybolt Furol Viscosity, (77°F), s	AASHTO T59	15-90	44	
Sieve Test, %	AASTHO T59	0.3 max.	0.01	
Storage Stability,24 hr.	AASHTO T59	1.0 max.	0.86	
Residue by Evaporation, %	CTM 331	57 min.	62.7	
Particle Charge	AASHTO T59	positive	positive	
Tests on Residue from Evaporation	CTM 331	18(88)		
Penetration, (77°F), 100g, 5s, dmm	AASHTO T49	40-90	45	
Ductility, (77°F), 5cm/min,mm	AASHTO T51	400 min.	660	
Torsional Recovery, %	CTM 332	18 min.	21.8	
9				
Remarks:				

Reviewed By:	77:1
-	(M. Sourson)
Sam W. Huddles	ton, Bituminous Laboratory Manager

3630 East Wier Avenue * Phoenix, Arizona 85040 * Telephone: (602) 437-0250



Mineral Aggregate Summary

Client: Pooled Fund Study Project Name: Asphalt Testing Services

Project No.: --Material Source: np

Material Supplier: Table Mountain

MACTEC Job No.: 5016-03-0007 Lab No.: 79086

Date Received: 07-27-2007 Report Date: 01-15-2008

Material: Type III Slurry Sand

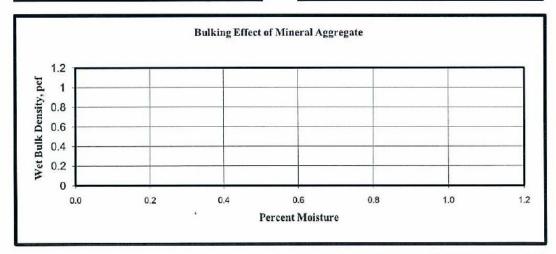
Grad	lation	
Test Method: ASTM C	136, C117	ISSA
Screen Size	% Passing	Spec
1/2" / 12.5 mm		
3/8"/ 9.5 mm	100	100
1/4" / 6.3 mm	89	
#4 / 4.75 mm	72	70-90
#8 / 2.36 mm	*41	45-70
#10 / 2.00 mm	36	
#16 / 1.18 mm	*25	28-50
#30 / 600 μm	*16	19-34
#40 /425 μm	13	
#50 / 300 μm	*10	12-25
#100 / 150 μm	7 .	7-18
#200 / 75 µm	*4.8	5-15

	Sand Equivaler	nt Test	
Test Method:	ASTM D2419		Spec
	SE Value:	85	45 Min.

Sulfate Soundness (source)					
Test Method: AASHTO T104	1				
	(%)	Spec			
Coarse:					
Fine:					

L.A. Abrasion (source)				
Test Method: ASTM C131				
Method:	% Loss	Spec		
100 Rev (%)				
500 Rev (%)				

Bulking	Effect
Test Method: ASTM C29	
Moisture Content	Wet Bulk Density, pcf



*: Does not meet Project Specifications

Specifications reference ISSA A105/A143

Design Guide Specifications for Slurry Seal

and Micro-Surfacing

Reviewed By:

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Mineral Aggregate Summary

Client: Pooled Fund Study Project Name: Asphalt Testing Services

Project No.: --Material Source: np Material Supplier: Lopke MACTEC Job No.: 5016-03-0007 Lab No.: 79087 Date Received: 07-27-2007 Report Date: 01-15-2008

Material: Type III Slurry Sand

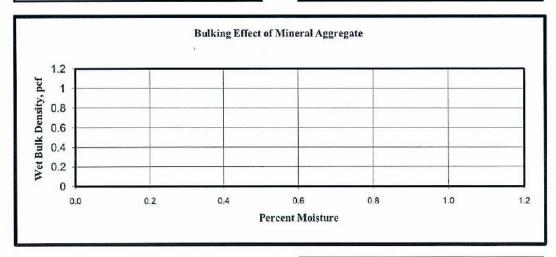
Grad	ation		
Test Method: ASTM C1	ISSA		
Screen Size	% Passing	Spec	
1/2" / 12.5 mm			
3/8"/ 9.5 mm	100	100	
1/4" / 6.3 mm	99		
#4 / 4.75 mm	*96	70-90	
#8 / 2.36 mm	*76	45-70	
#10 / 2.00 mm	68		
#16 / 1.18 mm	49	28-50	
#30 / 600 μm	34	19-34	
#40 /425 μm	30		
#50 / 300 μm	*26	12-25	
#100 / 150 μm	*21	7-18	
#200 / 75 μm	*17.2	5-15	

	Sand Equivaler	nt Test	
Test Method:	ASTM D2419		Spec
	SE Value:	*37	45 Min

Sulfate Soundness (source)					
Test Method: AASHTO T104	1				
	(%)	Spec			
Coarse:					
Fine:					

L.A. Abrasion (source)		
Test Method: ASTM C1	31	
Method:	% Loss	Spec
100 Rev ((%)	
500 Rev (

Bulking	Effect
Test Method: ASTM C29	
Moisture Content	Wet Bulk Density, pcf



*: Does not meet Project Specifications

Specifications reference ISSA A105/A143

Design Guide Specifications for Slurry Seal

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Asphalt Classification Summary

Client: Pooled Fund Study
Project Name: Automated Cohesion Testing
Asphalt Products Testing

MACTEC Job No.: 5016-03-0007 Date Reported: 05-08-2008 Material: CSS-1P

Source: Ergon, Waco Texas

	Pr	oject No.:	NP	
		mple ID.:	Tank 308	
	MACTEC	Lab No.:	79726	
	Date	Received:	11-19-2007	
	San	nple Date:	11-13-2007	
	San	ple Type:	Concentrate	
Tests on Emulsions	Test Method	Spec		
Saybolt Furol Viscosity. (77°F), s	AASHTO T59	15-90	16	
Sieve Test, %	AASTHO T59	0.3 max.	0.01	
Storage Stability,24 hr.	AASHTO T59	1.0 max.	0.42	
Residue by Evaporation, %	CTM 331	57 min.	67.7	
Particle Charge	AASHTO T59	positive	positive	
-				
Tests on Residue from Evaporation	CTM 331			
Penetration, (77°F), 100g, 5s, dmm	AASHTO T49	40-90	61	
Duetility, (77°F), 5cm/min,mm	AASHTO T51	400 min.	410	
Torsional Recovery, %	CTM 332	18 min.	20.3	
•				
Remarks:				la de la companya de

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Mineral Aggregate Summary

Client: Pooled Fund Study

Project Name: Asphalt Testing Services

Project No.: --

Material Source: Waco, Texas

Material Supplier: Delta Materials, Gr. 2

MACTEC Job No.: 5016-03-0007 Lab No.: 79753

Date Received: 11-27-2007 Report Date: 01-15-2008

Material: Type II Slurry Sand

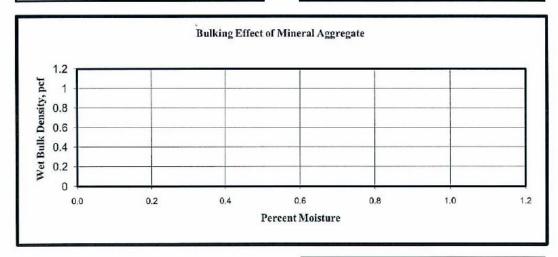
Grad	ation		
Test Method: ASTM C1	ISSA		
Screen Size	% Passing	Spec	
1/2" / 12.5 mm			
3/8"/ 9.5 mm	100	100	
1/4" / 6.3 mm	99		
#4 / 4.75 mm	*89	90-100	
#8 / 2.36 mm	*53	65-90	
#10 / 2.00 mm	46		
#16 / 1.18 mm	*32	45-70	
#30 / 600 μm	*22	30-50	
#40 /425 μm	18		
#50 / 300 μm	*15	18-30	
#100 / 150 μm	13	10-21	
#200 / 75 µm	7.8	5-15	

Sand Equivalent Test			
Test Method:	t Method: ASTM D2419		Spec
	SE Value:	63	45 Min.

Sulfate Soundnes	s (source)	
Test Method: AASHTO T104	1	
	(%)	Spec
Coarse:		
Fine:		

L.A. Abrasion (source)			
Test Method: ASTM C131			
Method:		% Loss	Spec
South State of the	100 Rev (%)		
	500 Rev (%)		

Bulking	Effect
Test Method: ASTM C29	
Moisture Content	Wet Bulk Density, pcf



*: Does not meet Project Specifications

Specifications reference ISSA A105/A143

Design Guide Specifications for Slurry Seal

and Micro-Surfacing

Reviewed By:

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Mineral Aggregate Summary

Client: Pooled Fund Study

Project Name: Asphalt Testing Services

Project No .: --

Material Source: Waco, Texas

Material Supplier: Delta Materials, Gr. 2

MACTEC Job No.: 5016-03-0007 Lab No.: 79753

Date Received: 11-27-2007 Report Date: 01-15-2008

Material: Type II Slurry Sand

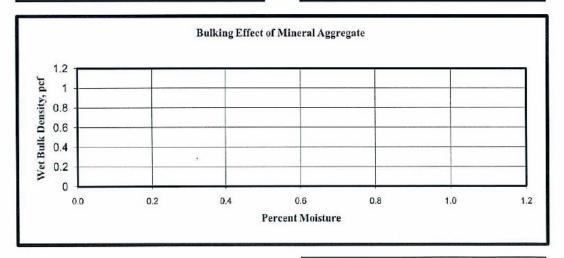
Gradation			
Test Method: ASTM C1	Txdot		
Screen Size	% Retained	Spec	
1/2" / 12.5 mm		0	
3/8"/ 9.5 mm	0	0-1	
1/4" / 6.3 mm	1		
#4 / 4.75 mm	11	6-14	
#8 / 2.36 mm	47	35-55	
#10 / 2.00 mm	54		
#16 / 1.18 mm	68 .	54-75	
#30 / 600 μm	78	65-85	
#40 /425 μm	82	100 100 00 00 11 TO	
#50 / 300 μm	85	75-90	
#100 / 150 μm	87	82-93	
#200 / 75 μm	92.2	85-95	

Sand Equivalent Test			
Test Method:	ASTM D2419		Spec
	SE Value:	63	45 Min.

Sulfate Soundness (source) Test Method: AASHTO T104			
			1110001
		(%)	Spec
	Coarse:		
	Fine:		

L.A. Abrasion (source)		
Test Method: ASTM C131		
Method:	% Loss	Spec
100 Rev (%)		
500 Rev (%)		

Bulking Effect		
Test Method: ASTM C29		
Moisture Content	Wet Bulk Density, pef	



Specifications reference TxDOT 2004
Standard Specifications

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MACTEC Engineering and Consulting, Inc

Mineral Aggregate Summary

Client: Pooled Fund Study Project Name: Asphalt Testing Services

Project No.: --Material Source: np Material Supplier: Lopke MACTEC Job No.: 5016-03-0007 Lab No.: 830152 Date Received: 02-12-2008 Report Date: 02-18-2008

Material: Type III Slurry Sand

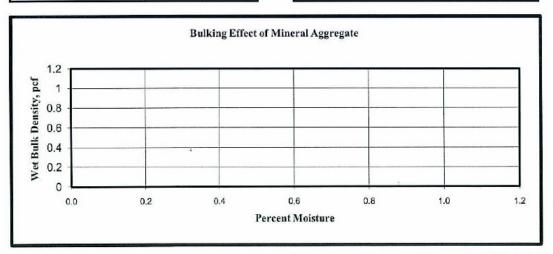
Gradation			
Test Method: ASTM	f C136, C117	ISSA	
Screen Size	% Passing	Spec	
1/2" / 12.5 mm			
3/8"/ 9.5 mm	100	100	
1/4" / 6.3 mm	99		
#4 / 4.75 mm	87	70-90	
#8 / 2.36 mm	55	45-70	
#10 / 2.00 mm	48		
#16 / 1.18 mm	34	28-50	
#30 / 600 μm	24	19-34	
#40 /425 μm	21		
#50 / 300 μm	18	12-25	
#100 / 150 μm	15	7-18	
#200 / 75 μm	11.9	5-15	

	Sand Equivaler	nt Test	
Test Method:	ASTM D2419		Spec
	SE Value:	*43	45 Min.

Sulfate Soundness (source) Test Method: AASHTO T104		
Coarse:		
Fine:		

L.A. Abrasion (source)		
Test Method: ASTM C131		
Method:	% Loss	Spec
100 Rev (%)		
500 Rev (%)		

Bulking Effect		
Test Method: ASTM C29		
Moisture Content	Wet Bulk Density, pcf	



*: Does not meet Project Specifications

Specifications reference ISSA A105/A143

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MACTEC Engineering and Consulting, Inc

Mineral Aggregate Summary

Client: Pooled Fund Study Project Name: Asphalt Testing Services

Project No.: --Material Source: np Material Supplier: Lopke MACTEC Job No.: 5016-03-0007 Lab No.: 830257 Date Received: 03-06-2008 Report Date: 05-08-2008

Material: Type III Slurry Sand

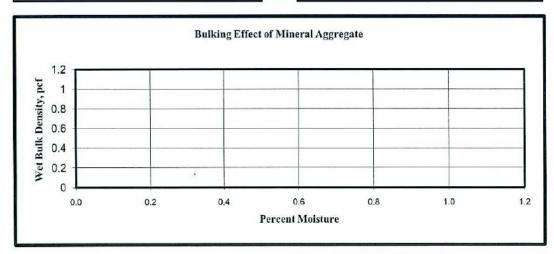
Gradation			
Test Method: ASTM C136, C117		ISSA	
Screen Size	% Passing	Spec	
1/2" / 12.5 mm			
3/8"/ 9.5 mm	100	100	
1/4" / 6.3 mm	99		
#4 / 4.75 mm	85	70-90	
#8 / 2.36 mm	55	45-70	
#10 / 2.00 mm	53		
#16 / 1.18 mm	35	28-50	
#30 / 600 μm	22 .	19-34	
#40 /425 μm	20		
#50 / 300 μm	19	12-25	
#100 / 150 μm	15	7-18	
#200 / 75 μm	11.7	5-15	

	Sand Equivaler	nt Test	
Test Method:	ASTM D2419		Spec
	SE Value:	47	45 Min.

Sulfate Soundness (source) Test Method: AASHTO T104		
Coarse:		
Fine:		

L.A. Abrasion (source)			
Test Method: AST	M C131		
Method:		% Loss	Spec
100	Rev (%)		
500	Rev (%)		

Bulking Effect		
Test Method: ASTM C29		
Moisture Content	Wet Bulk Density, pcf	



Specifications reference ISSA A105/A143

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MACTEC Engineering and Consulting, Inc

Mineral Aggregate Summary

Client: Pooled Fund Study Project Name: Asphalt Testing Services

Project No.: --Material Source: np

Material Supplier: Table Mountain

MACTEC Job No.: 5016-03-0007 Lab No.: 830359 Date Received: 03-27-2008 Report Date: 05-08-2008

Material: Type III Slurry Sand

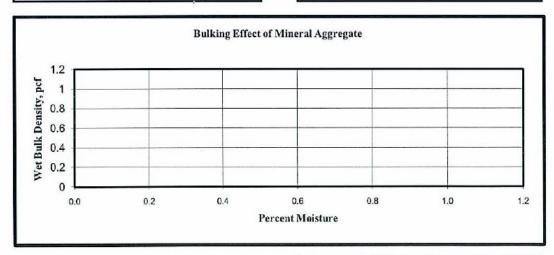
Grad	dation		
Test Method: ASTM C	136, C117	ISSA	
Screen Size	% Passing	Spec	
1/2" / 12.5 mm			
3/8"/ 9.5 mm	100	100	
1/4" / 6.3 mm	100		
#4 / 4.75 mm	87	70-90	
#8 / 2.36 mm	67	45-70	
#10 / 2.00 mm	64		
#16 / 1.18 mm	45	28-50	
#30 / 600 μm	30	19-34	
#40 /425 μm	25		
#50 / 300 μm	19	12-25	
#100 / 150 μm	13	7-18	
#200 / 75 µm	9.1	5-15	

	Sand Equivaler	t Test	
Test Method:	ASTM D2419		Spec
	SE Value:	79	45 Min.

Sulfate Soundnes	s (source)	
Test Method: AASHTO T104	1	
	(%)	Spec
Coarse:		
Fine:		

L.A. Abr	asion (source)	
Test Method: ASTM C	2131	
Method:	% Loss	Spec
100 Rev	(%)	
500 Rev	(%)	

Bulking	g Effect
Test Method: ASTM C29	
Moisture Content	Wet Bulk Density, pef



Specifications reference ISSA A105/A143

Design Guide Specifications for Slurry Seal

and Micro-Surfacing

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Asphalt Classification Summary

Client: Pooled Fund Study
Project Name: Automated Cohesion Testing
Asphalt Products Testing

MACTEC Job No.: 5016-03-0007 Date Reported: 05-08-2008 Material: Ralumac

Source: SemMaterials, L.P.

	Pr	oject No.:	NP		
		mple ID.:	NP		
	MACTEC	Lab No.:	830420		
	Date	Received:	04-08-2008		
	San	ple Date:	04-02-2008 Concentrate		
	Sam	ple Type:			
Tests on Emulsions	Test Method	Spec			
Saybolt Furol Viscosity, (77°F), s	AASHTO T59	15-90	28		
Sieve Test, %	AASTHO T59	0.3 max.	0.10		
Storage Stability,24 hr.	AASHTO T59	1.0 max.	0.58		
Residue by Evaporation, %	CTM 331	57 min.	64.5		
Particle Charge	AASHTO T59	positive	positive		
Tests on Residue from Evaporation	CTM 331				
Penetration, (77°F), 100g, 5s, dmm	AASHTO T49	40-90	84		
Ductility, (77°F), 5cm/min,mm	AASHTO T51	400 min.	866		
Torsional Recovery, %	CTM 332	18 min.	19.2		
	¥				
Remarks:					

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65 2000000000000000000000000000000000000	100-	Donneter	
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Phoenix, Arizona 85040

TEST	TEST RESULTS	Mix	M		MZ		CIE		T IN		CIA	
		Auto/Man	AUTO	AUTOMATIC	AUTOMATIC	MATIC	AUTO	AUTOMATIC	AUTO	AUTOMATIC	AUTO	AUTOMATIC
		Replicates	1	2	1	2	1	2	1	2	1	2
Humidity	Temp. ('C)	Curing(min)	TEMPLE	2	TEMPLE	20	TEMPLE	2047-01	TEMPLE	20	TEMPLE	2047-01
20%	10	15	1.8 N	2.1 N	1.3 N	1.6 N	3.5 N	4.5 N	2.8 N	2.5 N	4.0 N	6.1 N
20%	10	30	2.1 N	2.3 N	Z 6.	2.0 N	4.9 N	2.0 N	3.6 N	2.8 N	2.0 N	4.7 N
20%	10	09	3.1 Z	3.9 N	1.6 N	1.9 N	4.7 N	2.8 N	3.4 N	3.8 N	4.3 N	4.2 N
20%	10	06	2.7 N	3.2 N	2.1 N	1.6 N	7.2 N	8.5 N	3.3 N	3.0 N	3.0 N	4.9 N
20%	10	120	3.1 N	3.4 N	2.4 N	7 6. L	8.5 N	8.8 N	4.6 N	2.8 N	4. Z	4.2 N
20%	10	180	N 6.4	N 6.4	2.3 N	2.1 N	8.9 NS	8.9 NS	4.5 N	N 6.9	2.6 N	5.2 N
%09	10	240	2.9 N	6.5 N	4.2 N	3.0 N	9.9 SS	9.5 S	11.9 SS	12.0 S	0.8 N	0.9
20%	25	15	2.5 N	3.3 N	1.9 N	1.3 N	8.8 N	8.0 N	3.1 N	2.7 N	4.7 N	5.5 N
%09	52	30	4.5 N	3.8 N	1.6 N	2.1 N	11.5 N	11.0 N	4.6 N	5.2 N	7.0 N	6.1 N
20%	25	09	7.2 N	4.3 N	2.4 N	2.2 N	9.4 S	8.9 NS	5.2 N	4.8 N	N 6.4	6.3 N
20%	25	06	8.6 NS	9.8 NS	3.9 N	3.8 N	13.1 S	11.18	0.0 0.0	2.9 N	7.6 N	7.7 N
20%	25	120	8.6 S	9.4 S	3.9 N	3.4 N	12.6 SS	11.0 SS	7.3 N	0.7 N	8.4 NS	9.8 NS
20%	25	180	11.9 SS	10.3 SS	2.5 N	4.9 N	17.7 SS	13.1 SS	8.1.8	10.0 S	6.6 S	11.28
20%	25	240	10.9 SS	11.8 SS	6.9 S	6.3 S	9.9 SS	15.8 SS	11.8 SS	9.5 SS	9.7 SS	12.8 SS
20%	35	15	2.2 N	2.0 N	3.0 N	3.1 N	8.2 N	7.6 N	3.1 N	3.1 N	6.3 NS	6.9 NS
20%	35	30	3.4 N	4.0 N	5.2 N	3.7 N	9.2 N	8.8 N	4.7 N	3.2 N	7.6 NS	9.6 NS
%09	35	09	3.9 N	4.3 N	5.3 N	5.2 N	10.2 NS	0.8 N	4.1 Z	5.0 N	8.9 NS	8.0 NS
20%	35	06	0.6 N	6.2 N	8.1 NS	6.2 NS	12.0 S	13.3 S	2.6 N	3.8 N	9.6 NS	15.3 NS
20%	35	120	6.8 NS	8.0 NS	10.2 NS	8.0 NS	11.1 SS	10.1 SS	8.2 NS	8.8 NS	10.9 NS	10.1 S
20%	35	180	13.9 S	14.2 S	15.0 S	13.6 S	11.1 SS	9.7 SS	11.4 S	11.8 S	10.2 S	8.4 S
20%	35	240	14.4 SS	13.5 SS	12.7 SS	13.7 SS	16.5 SS	13.8 SS	12.7 SS	12.4 SS	13.5 SS	11.3 SS
%06	10	15	1.8 N	3.7 N	2.2 N	1.1 N	3.7 N	2.1 N	2.1 N	3.1 N	0.6 N	5.1 N
%06	10	30	2.8 N	2.1 N	1.8 Z	1.8 N	3.6 N	3.1 N	2.7 N	2.2 N	5.2 N	4.6 N
%06	10	09	2.7 N	2.4 N	1.6 N	2.0 N	7.4 Z	5.4 N	3.3 N	3.2 N	5.7 N	6.5 N
%06	10	06	3.9 N	4.2 N	1.3 N	1.8 N	8.0 N	8.0 N	3.4 N	2.1 N	4.6 N	5.1 N
%06	10	120	2.7 N	4.1 N	1.3 N	2.0 N	8.3 NS	8.3 N	2.8 N	2.9 N	3.6 N	6.2 N
%06	10	180	4.2 N	3.7 N	1.5 N	2.6 N	10.2 NS	10.9 NS	2.9 N	4.7 N	4.6 N	4.2 N
%06	10	240	0.9 N	6.8 N	2.9 N	1.6 N	8.6 SS	7.6 SS	3.6 N	4.6 N	5.7 N	5.1 N
%06	25	15	1.8 N	2.0 N	2.1 N	2.4 N	6.7 N	0.6 N	4.2 N	3.8 N	5.4 N	7.9 N
%06	25	30	2.8 N	2.2 N	1.7 N	1.5 N	7.6 N	7.6 N	3.7 N	3.6 N	7.0 N	6.7 N
%06	25	09	2.3 N	2.2 N	2.8 N	2.3 N	8.2 NS	8.7 NS	3.4 N	5.5 N	N 6.9	8.4 N
%06	25	06	2.2 N	2.0 N	2.1 N	2.7 N	11.7 S	10.8 S	2.8 N	5.8 N	7.8 N	8.7 N
%06	25	120	2.2 N	2.1 N	2.9 N	4.1N	10.6 S	9.9 SS	5.3 N	6.2 N	8.2 N	8.8 N
%06	25	180	3.2 N	1.8 N	6.5 N	N 9.6	10.6 S	9.2 S	8.8 N	6.8 N	0.6 N	8.1 N
%06	25	240	3.5 N	3.4 N	10.6 NS	11.9 NS	10.5 SS	9.6 SS	11.5 N	7.9 N	7.9 NS	9.8 NS
%06	35	15	3.0 N	3.2 N	1.6 N	2.1 N	5.5 N	0.0 N	3.9 N	3.3 N	N 6.9	7.3 N
%06	35	30	2.0 N	2.7 N	2.5 N	1.9 N	5.3 N	7.1 N	4.1 N	3.5 N	7.3 N	6.7 N
%06	35	09	2.8 N	2.7 N	3.0 N	2.2 N	8.2.S	6.5 S	2.0 N	5.7 N	7.0 N	8.2 N
%06	35	06	4.2 N	2.6 N	3.8 N	3.9 N	5.6 SS	6.0 SS	4.6 N	4.6 N	8.0 N	7.2 N
%06	35	120	5.4 N	7.1 N	5.1 Z	2.8 N	15.7 SS	14.4 SS	N 8.4	5.6 N	8.5 N	8.0 N
%06	35	180	10.4 NS	13.1 NS	6.1 N	5.7 N	11.9 SS	9.9.55	4.4 N	0.9	9.2 N	Z 8.Z

ı
0.0 0.6
0.0 N
Z O
10.0 N
12.0 N
15.0 NS
17.0 NS

Parameter	Units	Values		Tes	t No.		
		High (H)	Low (L)	1	2	3	4
1. Cure Temp	С	2	-2	L	L	Н	Н
2. Cure Time	min	3	-3	L	Н	L	Н
3. Cure Humidity	%	10	-10	Н	L	L	Н

APPENDIX F UPDATED WORK PLAN FOR PHASE III

1.0 PHASE III OBJECTIVE

The objectives of Phase III is to actually use mix designs in accordance with the procedures outlined in this report on projects identified by the states supporting this study. Attempts will be made to place these mixes in a variety of environmental and traffic conditions.

2.0 GUIDELINES AND SPECIFICATIONS

It was first estimated that by the end of Phase II, the work plan would be considered to be essentially final. Due to the cancellation of the project, additional research is anticipated before final guidelines and specifications can be produced. Much of the Reference Manual, 1.5-day training course and the "tailgate" training are near completion. This chapter describes what has been done and what remains to be done on the phase.

3.0 PURPOSE OF PHASE III STUDY

The purpose of Phase III is to validate that mixes designed in the laboratory, using the new and revised procedures as outlined in Phase II, can actually be built in the field. This chapter presents the proposed Work Plan to complete the following tasks, as outlined in the original proposal:

- Develop guidelines and specifications for the proper use of slurry and microsurfacing.
- Develop a workshop training program that includes a pre-construction module to educate and inform agency, contractor, and material supplier personnel of the new design procedures and constructability issues.
- Construct and monitor pilot projects for the validation effort.
- Revise the procedures or the training program based on test section field performance.
- Prepare a Final Report documenting all the activities throughout the project.

4.0 TASK 1: DEVELOPMENT OF GUIDELINES / SPECIFICATIONS

During this phase of the work, the project team will develop guidelines that can be used by both contractor and agency personnel that will aid them in the proper selection of projects and the appropriate use of these treatments. For example, the guidelines for proper project selection will address issues such as type and condition of the existing pavement. These treatments are not effective if placed on pavements in poor to bad condition. Additionally, the project team will address the differences between the S3 systems and provide guidance where

each will meet expected performance expectations. For example, if quick return to traffic and friction are important functional characteristics desired by the agency, the use of a high traffic mixture may be preferred over a low traffic one.

The guidelines will also address constructability issues that need to be considered during the placement of these techniques. This will include mixing, wetting, and adhesion at the placement site as well as techniques to preclude segregation of the mix and homogenous spreading of the mix over the pavement surface.

Guidance will be provided to both agency and contractor personnel regarding the things to evaluate for proper curing characteristics of the emulsion. It is also important that identification be made of those characteristics that are of utmost importance in assuring the long-term performance of the mix. This will be dependent on the quality and reproducibility of the mix design and the condition of the existing pavement.

The team will develop the necessary specifications for S3 mixes. Work on this effort has already begun. Working with existing specifications from agencies that have a great deal of experience with these systems as a starting point, we will include the new test methods and other appropriate sections in the specifications that we prepare.

5.0 TASK 2: DEVELOPMENT OF THE TRAINING PROGRAM

Under this task, the Fugro team will develop a comprehensive training program as the principal aid in the implementation of the new slurry/micro-surfacing mix design procedure. The program will include two primary training elements:

- A 1.5-day course designed to educate State highway agency personnel (at several levels), contractor personnel, and material suppliers on the technology and overall application of the new mix design procedure.
- A 1-hour presentation module that can be used to appraise inspectors and contractor personnel of the required new/improved construction procedures that have come about as a result of the new mix design procedure. We refer to this effort as a "tailgate" training package.

These two components will be treated as separate, but complementary, sets of training materials. A more detailed discussion of the development plans for each is provided below.

5.1 Slurry/Micro-Surfacing Mix Design Training Course

The training course to be developed under this effort will be designed to provide basic training on the development and application of the new mix design procedure. The training materials, as discussed in greater detail below, will include a Reference Manual, a set of training course

visual aids (in electronic format), and an Instructor's Guide. The course will be designed for presentation over a 1.5-day period and will include two workshops. In developing the workshops, the goal will be to incorporate "hands-on" exercises that not only advance the learning, but help generate some enthusiasm and interaction among the participants, as well.

The materials for this course will be developed to be compatible with National Highway Institute's (NHI's) Guidelines for Training Materials because the NHI has set the standard for training materials.

5.2.1 Reference Manual

This manual will be a detailed, stand-alone document that covers all the key aspects of the new mix design procedure. It will be referenced throughout the course to help familiarize the participants with the contents and improve its use as a technical resource. Table F-1 provides an outline of the manual as it is currently envisioned.

Technical leadership for this effort will be supplied by Jim Moulthrop. The key staff that will participate in its development include Glynn Holleran, Dragos Andrei, Steven Seeds, and David Peshkin.

Table F.1: Draft Outline for Reference Manual

Section	Title/Description
1	Introduction
	Background
	Slurry/Micro-Surfacing Overview
	Objectives and Scope of Manual
2	Project Selection Criteria
3	Pre-Construction Requirements
4	Specifications
5	Mix Design Criteria
	Binder Requirements
	Aggregate Requirements
	Blending Requirements Text Mathematican Discontinuous
6	Test Methods and Procedures
	Framework Machaniana
	Mechanisms Oignificance of Test Variables
	Significance of Test Variables
7	Protocols Construction Considerations and Limitations
/	
	 Project Geometry Weather Limitations
8	Construction Operations
0	Surface Preparation
	Equipment and Calibration Requirements
	Mix Design Verification
	Stockpile Management
	Troubleshooting
	Inspection and Workmanship Requirements
9	QC/QA Requirements
	Pre-Construction and Construction Testing Requirements
	Frequency and Type of Test
10	Troubleshooting
-	References
-	Appendices
	Test Methods
	Specifications

5.2.2 Visual aids

Visual aids are required to present the training course material in a clear, consistent, and organized fashion. They will be prepared in electronic format using Microsoft PowerPoint®. This is a standard tool for NHI training courses and is very effective for both preparation and presentation of visual aids. Where appropriate, animation will be included in certain slide images to either emphasize certain points or provide an additional aid in understanding the message. Video clips of certain processes will also be included where they can provide the most benefit.

The organization of the course will closely follow that of the Reference Manual. Each section of the report will be translated into a training module with a presentation length ranging from 20 to 90 minutes, depending on the topic (see preliminary agenda in Table F-2). In addition, two workshops will be prepared. A hands-on workshop involving the use of the different types

of laboratory equipment will developed for conduct on the afternoon of the first day of training. The second workshop will be prepared in a game format (such as Jeopardy) to test learning and emphasize key points relative to the slurry/micro-surfacing construction process. It will be conducted during the morning of the second day of training.

Table F.2: Preliminary Agenda for 1.5 Day Training Course

D	ay	Module	Title
1	AM	1	Course Overview
		2	Introduction to Slurry/Micro-Surfacing
		3	Project Selection Criteria
		4	Preconstruction Requirements
		5	Mix Design Criteria
	PM	6	Test Methods and Procedures
		7	Laboratory/Mix Design Workshop
2	AM	8	Construction Considerations and Limitations
		9	Construction Operations
		10	QC/QA Requirements
		11	Construction Workshop
		12	Summary and Closing Remarks

5.2.3 Instructor's Guide

The Instructor's Guide will be developed to provide detailed assistance to the instructor for the successful presentation of the training course. It will contain the following information:

- General Introduction (title page, table of contents, general course information, learning objectives, description of target audience, assumed course prerequisites, class schedule, key technical references, and sources of additional information).
- General Training Course Set-Up and Wrap-Up Procedures (preparatory activities, host agency interactions, room set-up, and pre- and post-workshop housekeeping items).
- Annotated Outline by Session (including learning objectives, key discussion points, answers to typical questions, time allotments, areas to reduce if time becomes an issue, copies of visual aids with annotations, and associated workshops or other learning evaluation/application methods).

David Peshkin will take the lead in developing the visual aids and the Instructor's Guide. Development assistance will be provided by Steve Seeds and Dragos Andrei. Jim Moulthrop will serve in both an advisory and review capacity.

5.3. PRE-JOB TRAINING MODULE

It is anticipated that this project will result in several significant modifications to the slurry/micro-surfacing construction processes as well as mix design procedures. Consequently, the purpose of this effort is to develop a pre-job training module, which will

include a section on project safety, so that the "must know" information can be shared with agency and contractor personnel. This information will be extracted from the Reference Manual and a stand-alone document prepared for presentation and discussion during a meeting (similar to a pre-construction meeting) that will be held prior to the beginning of a slurry surfacing or micro-surfacing project. In addition, an easy to use, pocketsize guidebook will be prepared so that both agency and contractor personnel can take it into the field.

Jim Moulthrop will oversee and participate heavily in this effort. He will be assisted by Dragos Andrei and David Peshkin.

5.4 TASK 3: CONSTRUCTION OF PILOT PROJECTS FOR FIELD VALIDATION OF DESIGN PROCEDURES

The purpose of this work plan is to develop guidelines for the construction and evaluation of test sections for the validation of slurry seal and micro-surfacing mix design procedures. These guidelines indicate the type of equipment used and evaluation of the construction of test sections. A factorial for the determination of the site locations including test section layout has also been developed. Finally, a monitoring plan has been developed to determine constructability, and both short-term and long-term performance of the test sections.

The LTPP program developed a study to determine the long-term performance of various maintenance treatments. Seven States participated in the construction of these test sections. The layout of these sections along with their site selection provided valuable information for the economical evaluation of the test sections. A similar plan is proposed for the validation of the slurry and micro-surfacing mix design procedure.

Fortunately, there has been widespread support for this study, which includes agencies from the States noted in Chapter 1. It is hoped that additional States may add their support before the conclusion of this study. These States provide a diverse set of climatic conditions ideally suited for this study. Their support in sponsoring and constructing test sections for slurry surfacing and micro-surfacing will greatly benefit this study.

5.4.1 Identification of Test Sections

5.4.1.1 Site Selection

Many factors affect the performance of slurry seal and micro-surfacing projects. These include climate, traffic, and condition of the existing pavement prior to the application, workmanship, and the mix design. A matrix factorial considering each of these variables has been developed and is noted in Table F-3. Consideration was given to the cost of constructing these test sections during the development of this factorial. It is important to consider each of the factors affecting performance to provide the team with the proper information to perform a validation of the procedures.

Table F.3: Site Selection Matrix Factorial

Traffic	Surface Type	Climatic Region			
		Wet-Freeze	Wet-No Freeze	Dry-Freeze	Dry-No Freeze
>25,000 ADT	HMAC	*(1,2)	*(1,2)	*(1,2)	*(1,2)
Moderate >10,000<25,000 ADT	PCC HMAC	*(1,2)	*(1,2)	*(1,2)	*(1,2)
	PCC				

^{*1-}Coarse

An examination of the site conditions prior to selection must be conducted to insure uniformity among the test sections. The first step is to insure that the site is long enough to accommodate the number and length of test sections to be included in the site. Particular attention to entrance and exit ramps should be taken to insure uniform traffic among the test sections. It is preferable that the agencies avoid roadways that have sharp turns and superelevation in order to mitigate the interaction of the tire and the pavement between different test sections. It is recommended that the test sections be located on a relatively straight roadway with uniform vertical grade. The existing condition of the pavement (surface distress) should also be determined. It is recommended to select pavements with little or no distress. However, sites with limited distress will be accepted as long as the site has uniform conditions (raveling, bleeding, transverse cracks, etc.). Distress surveys using the LTPP Distress Identification Manual (DIM) shall be conducted on all sites prior to placement of the treatments to document the pavement condition. This manual contains survey sheets and specific instructions on conducting these types of distress surveys.

Ride quality has been shown to impact the rate of deterioration of pavements. It is recommended that the surface of the pavement be smooth and provide an excellent ride level to reduce the effects this may have on individual sections within a test site. As a target, the existing surface should have a prorated IRI of less than 158 mm per 1,000 m (100 in. per mile) as measured by a calibrated profiler.

A site will be required in each of the four climatic regions. The current project States provide this diversity of climate regions. The four climatic regions used by the LTPP program were Wet-Freeze, Wet-No-Freeze, Dry-Freeze, and Dry-No-Freeze. These regions were determined by the amount of average annual precipitation and duration of freezing temperatures during an average year. The type of climate has a significant impact on the selection of the mix. In warm and dry climates, the rate of evaporation is greater and slow setting emulsions are desired. The opposite is true of wet and cold climates. The rate of curing can be altered by the amount of water, cement, emulsion, and set control chemicals. The four climatic regions will provide an opportunity to apply different mix designs using the new recommended procedures.

^{*2-}Coarse (rut, or level-up)

^{**}Equivalent Single Axle Load

The effects of traffic also have an impact on the rate of deterioration. Traffic loadings may be determined in many different ways; unfortunately, there is no consistent national traffic loading reporting scheme. Many States do not utilize a consistent traffic loading procedure. The most prevalent way to express traffic loadings is the Equivalent Single Axle Load (ESAL), which is based on Average Daily Traffic, Percent Trucks, Truck Factors, and other conditions. Another way is to express traffic applications as Average Daily Traffic (ADT) with a certain percentage of trucks. Other States use a Traffic Index based on ESAL values. Slurry seals and microsurfacing are preventive maintenance treatments and are not used as enhancements to the structural capacity of the pavement. Because ESAL values are used primarily for the structural design of pavements and utilize an ADT and percent trucks, the expression of ADT and percent trucks is recommended to express traffic applications.

Table F-3 presents the recommended matrix factorial for site selection. The amount of traffic for the factorial has been divided into two levels: high and moderate. The high traffic level ranges from 25,000 ADT and above (>10 Million ESALs). The moderate traffic level ranges from 10,000 ADT to 25,000 ADT (approximately 4-10 Million ESALs over 20 years with 10 percent trucks).

The variation of the type of subgrade soil and base materials (and their properties) between different sites will have an effect on the structural performance of the roadway. The costs associated with sampling and testing these materials at each site location is considered prohibitive. This would also burden the participating State Departments of Transportation with additional responsibilities. Therefore, this sort of sampling and testing will not be undertaken.

The primary focus of this study will be on the constructability of the recommended mix-designs and their performance compared to existing mix design procedures or various maintenance treatments. It is not recommended that subgrade soil and base types be included in the site selection. These treatments will be placed within the same site location and the structure should be approximately the same. If changes in pavement type or structural design are identified, the site should be adjusted to eliminate the presence of multiple pavement structures. The structural capacity of the pavement is important in determining the life span of the pavement. It is recommended that only those sites with sufficient remaining life (five years) be used for this study. This should prevent the need for maintenance and rehabilitation activities prior to completing the study.

5.4.2 Test Section Layout

The section layout will depend on the number of test sections desired for the study. As a minimum, the sections should include a control section without treatment and a slurry seal or micro-surfacing test section. This will provide validation of the constructability of the recommended mix design as well as the effect of the treatment on extending the existing

pavement's life. However, this type of experiment does not allow a comparison of the improvement of the recommended mix design to existing mix designs or other treatments. Multiple treatment sections (e.g., slurry seal and micro-surfacing systems with different binders) along with the control are recommended to obtain the amount of information necessary for a complete evaluation and validation.

Multiple test sections using micro-surfacing may be placed using different types of polymers (e.g., natural rubber, synthetic rubber latex [SBR], or various combinations). It is recommended that a section using the ISSA design procedure be placed along with one of the recommended design procedures to determine the long-term performance of each type of mix design. The number of treated sections will depend on the results of the Phase II study and the desire of States to include supplemental sections to evaluate additional materials/treatments. Each treatment will be placed according to the construction guidelines described in this work plan. The recommended length of the test sections will be determined by the project team with approval from the panel and will be a minimum of 152 m (500 ft) and a maximum of 305 m (1,000 ft). The length of each test section will remain constant for each site in this study.

5.4.3 Construction Guidelines

The construction guidelines to be developed are intended to insure proper placement of the material. Direct discussions between the teams, the contractor, and the participating State agency will be held prior to construction and will be part of the training program outlined in Section 4.3. This interaction is critically important for developing the participants' necessary understanding of the objectives of the experiment and the need for cooperation in adhering, as much as possible, to the requirements outlined in this report.

Many of the problems encountered with slurry seal and micro-surfacing can be attributed to improper placement of the material. These problems include the field conditions at the time of placement (i.e., wet surface, debris present, and temperature). The LTPP program was able to use of the same crew and equipment in the SPS-3 studies: HMAC Maintenance Treatments. It would be preferable for the same crew, equipment, and materials (aggregate and emulsion) to be used to apply all treatments in this project in order to reduce the impact of variation between treatment locations. However, due to the extreme effort of mobilizing the same crew and equipment to each State, this is cost prohibitive.

To account for the variables represented by differing crews and equipment, documentation on the type of equipment and source of materials is recommended to record the potential impacts these may have on the performance of the treatment. The project team has provided a plan, discussed below. Forms to obtain data on the lay down procedures are provided in Appendix G.

5.4.3.1 Pre-Construction

All cracks that are greater than 6 mm wide (0.25 in) should be sealed prior to application of the treatment. It is not anticipated that patching will be required because of the pre-qualifying condition of the test sites. If patching is required, it must be performed prior to the distress survey. The site conditions prior to construction will be recorded and will include the following:

- Pavement Distress using the LTPP DIM(2)
- Type of Surface Material and Construction History (age)
- ADT and Percent Trucks
- Climate
- QA Procedures Developed in Task 1
- Calibration of Equipment

Prior to construction, the pavement must be in a dry condition and free of debris.

5.4.3.2 Construction

The following construction guidelines must be followed:

- The treatment mix design can be placed only after the contractor has satisfactorily demonstrated proper placement procedures on non-test section locations.
- All transverse construction joints must be placed outside the test sections (e.g., within the transitions between test sections).

The distance between the transition areas must be sufficient to allow changes in materials during construction. The distance is required to accommodate changes in material type in a manner that will reduce the influence on the properties of the finished pavement. Each test section will have a minimum of 30 m (100 ft) before and after the monitored length to provide sufficient production to develop consistency after changes in materials.

The mixture for the treatment will be documented using the forms in Appendix G, which include the type and quantities (rates) for each of the following:

- Polymer-modified emulsified asphalt cement
- Well-graded crushed mineral aggregate
- Mineral filler (normally portland cement or lime)
- Water
- Other mixing aid additives (normally emulsifying agents)

The project team shall provide the mix design information to the contractor and agency prior to the beginning of the project.

The equipment used for the application of the treatment shall also be documented using the forms in Appendix G, which will contain the following information:

- Type of paving equipment (continuous, truck-mounted)
- Type of spreader box

The breaking and curing rates of the treatment will be collected and entered on the Equipment Form provided in Appendix G.

An agency that desires to participate, but finds it necessary to deviate from some of the guidelines described in the report, should review these deviations with the research team. The team will assess the implications of these deviations on the study objectives. If the implications of the non-compliance appear minimal, the deviations will be accepted; if the implications appear to represent a major impact, the team will suggest alternatives for consideration by the participating agency.

5.4.3.3 Post-Construction

It is recommended that the test sections be allowed to cure properly prior to the application of traffic loadings to prevent premature damage. Evaluations of the test sections will be conducted immediately after construction, prior to opening the site to traffic one month after construction, and one year after construction. It is important that the sections be marked with tape, paint, or placards to identify the test sections. It is also recommended that the exact section locations be obtained using Geographical Positioning Systems (GPS), route, milepost, or other reference information. A section identification code will be developed to identify individual sections in the study. The evaluations of these test sections will be described in detail in the following sections.

5.5 PAVEMENT EVALUATION

Each pavement evaluation before, immediately after, and one year after construction, will consist of a detailed survey of the existing pavement distress using the LTPP DIM. The post construction surveys will also include comments of any abrasion, delamination, drag marks by the spreader box, wash boarding, and measurements of surface texture and noise. Segregation and flushing are identified in the LTPP DIM.

A survey form has been provided in Appendix G that summarizes the distress information obtained from the field. The amount of rutting will be measured with a 1.8-m (6-ft) straight

edge every 15 m (50 ft) within the test section. If a high-speed profiler is used having five or more sensors to obtain ride quality information, the rutting will be obtained from this information. The texture will be determined using sand patch or other accepted test procedures. After the test section is open to traffic, the noise level will be determined from a safe distance from the pavement edge (edge of shoulder) if the agency has this type of equipment available.

If subgrade and base properties are still desired by the agencies, then a sampling and testing plan will be developed to accommodate the collection of these data. Structural testing using a Falling Weight Deflectometer (FWD) may also be considered to determine the variability of the pavement structure throughout each of the test sites to determine the remaining service life or to identify if there are underlying structural problems. An evaluation of the costs associated with this additional data collection effort should be considered by the agency before adopting this effort because it is beyond the scope of this project.

5.5.1 Revision of Procedures and Training Programs

Based on the feedback from participants in the training modules and the contractor and agency personnel involved with the construction and evaluation of the pilot projects, adjustments will be made (where necessary) to the guidelines, specifications, and training programs to make them clearer and more "user friendly."

5.6 REFERENCES

- 1. SPS-3 Construction Report, SHRP Contract H-101, Brent Rauhut Engineering, SHRP Southern Region Coordination Office, Strategic Highway Research Program, Federal Highway Administration, Washington, DC, January 1991.
- 2. Distress Identification Manual for the Long-Term Pavement Performance Program, FHWA-RD-03-031, Federal Highway Administration, Washington, DC, June 2003.